REPORT

OF THE

Commissioner of Agriculture.

1886.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1887.

[PUBLIC RESOLUTION—No. 29.]

Joint resolution for printing report of Commissioner of Agriculture.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That there be printed four hundred thousand copies of the annual report of the Commissioner of Agriculture for the year eighteen hundred and eighty-six; three hundred thousand copies for the use of members and delegates of the House of Representatives, and seventy-five thousand copies for the use of members of the Senate, and twenty-five thousand copies for the use of the Department of Agriculture.

SEC. 2. That the sum of two hundred thousand dollars, or so much thereof as may be necessary, is hereby appropriated, out of any money in the Treasury not otherwise appropriated, to defray the cost of the publication of said report.

Approved, August 4, 1886.

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ERRATUM.

Transpose lines 19 to 25 to follow line 46—page 224.

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REPORT

OF THE

COMMISSIONER OF AGRICULTURE.

DEPARTMENT OF AGRICULTURE,
Washington, D. C., November 15, 1886.

To the PRESIDENT:

I respectfully submit my second annual preliminary report as Commissioner of Agriculture.

American agriculture has developed colossal proportions. With more than two centuries of growth, much the larger part of its development has come from the thought and labor of the last thirty years. In that time wheat has quadrupled its product, corn has a threefold production, and cotton has doubled its annual crop. For every pound of meat and gallon of milk in 1856 there are three in 1886, and more than four times as many pounds of wool. It is no idle boast that this country produces more than half the cotton of the world and three-fourths of the maize.

With production so varied that only the tropical fruits are lacking, and so abundant as to secure almost unexampled cheapness, it is certain that this is the best-fed nation on the globe. Meat, an occasional indulgence in many countries, is here the staple of nearly every meal, and the average of individual consumption is at least three pounds for every one consumed in Europe. Fruits are so abundant as to tax the power of home consumption, the surplus going to waste if not fed to farm animals. While the meats, wool, and corn, wine and oil, sugar and rice, and products of the dairy and of the orchard and garden, are mostly consumed at home, we are supplying the deficiencies of other countries, still shipping about two-thirds of our cotton, one-fourth of our wheat, and one-fifth of our pork products to foreign countries, and ever ready to enter any door of profitable consumption that opens to receive the surplus of our manufactured products of agriculture.

American agriculture is progressive. Its comparatively low yields are due to the abundance and cheapness of virgin soil, and the desire to compass a wider land area in the regions of primitive cultivation. The rate of yield is increasing in older settlements under the influence of better methods, higher skill, and fertilizing restoratives. Its characteristic features are the application of labor-saving machinery,

deftness in manipulation, and mental alertness in management. Production has dispensed with half the muscular effort required by the former generation of farmers, and the result is less of drudgery and more of physical comfort and mental culture. The future is likely to witness a more rapid progress than has yet been recorded.

The results of production in the present season are favorable to the well-being of producer and consumer. The year has been one of medium fruitfulness. Drought, a specter which stalks so frequently over many a league of productive area, has this season been confined mainly to portions of two or three States west of the Mississippi, and even there has generally left an ample sufficiency for supply of local wants and avoidance of absolute distress. The cotton crop, wheat, and small grains are all of medium dimensions; corn is ample for all needs, while below an average yield; fruits and vegetables are of moderate abundance, and the grasses and forage crops, the most important source of our agricultural wealth, have in most sections been fairly productive. There is no scarcity either in the home supply or in the surplus necessary for any foreign demand, so that no curtailment of agricultural exports is expected. Thus the year to the husbandman has been one of average fruitfulness, of good markets, comparatively low prices, and moderate profits.

Such is the condition of that industry which this Department strives to foster, and such the relation which the farming class sustains to the stability, progress, and prosperity of the country. Surely it should furnish abundant reason for generous legislative support of all attempts made to increase production, to diversify crops, to preserve and enhance the fertility of the soil, to plant, to cultivate, to keep and reap more intelligently than those who have gone before, and to leave for those who follow us those methods and processes out of which are to be evolved the ultimate solutions of the problems of agriculture.

During the year it has been my privilege to inaugurate new and improved methods in the general administration of the Department; to give due attention to new and improved processes; and to introduce, from time to time, through the various special reports, whatever the scientific and experimental investigations carried on under my direction have suggested as being worthy of attention and trial by the progressive agriculturist. It is the aim of the Department under the present administration not only to extend the benefits of scientific and enlightened inquiry among the farmers and agricultural workers of our country, but also to induce a habit of thought among them which will lead to that practical experimentation in local soils and climates which is always necessary to prove the value or worthlessness of new theories in agriculture as applied under special conditions.

That the Department has been unusually active in this regard will

be proved, I think, by an examination of the detailed reports of its several divisions which follow, and that the information gathered has been diffused over a wide area is fully attested by the enormous demand for its published literature and the inquiries for information upon special topics from every section.

EXPERIMENTAL AGRICULTURE.

In a new country and upon a virgin soil nature responds so readily to the plainest cultivation that a maximum of muscle and a minimum of brain results in successful farming, but when generation after generation has drawn upon the stored fertility, and agricultural communities have to contend not only with well-worn land, but with dear labor and active competition from a distance, the prevailing conditions are far different. Labor-saving inventions are sought, more brain work becomes necessary, every year seems to bring a harder problem, and the modern farmer realizes the number of unknown quantities with which he has to deal and the need of bringing to his aid all the resources of modern science. No other occupation requires such intimate acquaintance with the many and mysterious laws of nature, or is so dependent upon the practical application of the latest and best of research in every branch of natural science. But although there is a general recognition of the value of science applied to agriculture, farmers will never be able to accomplish much by individual effort in solving the problems met with at every turn. In addition to all the recorded experience of the past, new experiments, to determine truths of practical value, are constantly needed. Some individual farmers have conducted experiments so carefully and persistently as to reach conclusions of general value. The work remaining to be done, however, is greater and more important than all that has been accomplished, and requires time and means which cannot possibly be supplied by farmers themselves singly or collectively. And however creditable the results of private effort in agricultural experiments, such labors are usually found fragmentary, disconnected, and only useful for local application. Moreover, so important is a correct plan, absolute accuracy of detail in execution, and unbiased interpretation of the results, that agricultural investigation, to be of public service, needs to be scientifically conducted by well-trained men. Baron Liebig said:

> When the practical man attempts exact methods he is almost invariably a sufferer. He seems to forget that man does not become intuitively acquainted with scientific procedure, but that this must be learned, like the skillful use of any complex instrument.

Hence the necessity for new provisions for such experimentation as is required by progressive agriculture and their better organization and maintenance.

All other industries and the public welfare are so dependent upon

the prosperity of agriculture in almost every country, that the investigation and experiment needed for the progress of farming in any given country has come to be acknowledged as work properly undertaken at public expense and under the direction of the state. The only question which appears to be open for discussion in this connection is as to the best provisions for that experimental work which is recognized as essential to the progressive agriculture of our times.

Institutions for this purpose, generally known as agricultural experiment stations, have been established and supported by public funds, some for nearly thirty years in many parts of Europe, and for a shorter time in several of the United States. The "station" is simply a comparatively new and improved method of conducting agricultural experiments. It is a place where discovery for the benefit of farming is made a regular business, with complete equipment, and managed by competent men. These establishments have become so valuable and popular in Europe, that they have rapidly increased in number, until there are now about one hundred and forty in operation.

Agricultural experiment stations in this country have been established in nine States, in the following order: Connecticut and North Carolina in 1877; New Jersey, 1880; New York, Ohio, and Massachusetts, 1882; Wisconsin and Alabama, 1883, and Maine in 1885. These are all distinctly independent institutions, with their own organizations, and supported by State appropriations or special tax. Some, however, are located at State agricultural colleges, and officered by the college professors. These stations differ greatly in their organization, facilities, and work. Some are required to control the business in commercial fertilizers in their respective States, while others do nothing of this kind. In New Jersey and North Carolina at least $10,000 is expended yearly, mainly in laboratory work and the publication of results, although land is somewhat used in New Jersey. In Alabama and Wisconsin large areas of land are used—100 acres or more; in Ohio, 25 acres; and in New York about 125 acres.

In several other States there are provisions made for systematic experiment work at the agricultural colleges and State universities by appropriations from college funds and the assignment of professors to this duty. In some cases the results are becoming very valuable, at least locally, while in others the efforts are feeble and uncertain.

Other States and colleges are considering the inauguration of experimental inquiry, and efforts in this direction are apparently limited only by lack of means. Experimental agriculture is expensive. It means constant outlay for the good which will come of it, and the greater the outlay the more valuable the returns. An experiment station is a place to spend money systematically, judiciously, with no apparent return, but always for the purpose of ultimately saving much more. And this saving, being in the production of the neces-

saries of life, results in benefit not only to the farmers, but to every class in the community. The fact is well known that the endowments of most of the State agricultural colleges are very meager; in several instances even insufficient to maintain a creditable educational institution. In such cases expenditures for experimentation are impossible. Yet to do good work a station should have well-appointed buildings, expensive apparatus, books and periodicals, and a handsome and certain annual income. Able men should be secured and salaries paid according to the nature of the work. The colleges generally cannot be expected to assume such burdens, and it is probable that the States most needing such stations will be the last to create them, if ever done.

With a number of well-equipped and fairly maintained stations in as many different States, operating without communication, much less co-operation, and often in diverse lines of inquiry, the results are but a fraction of what they might be if provision were made for joint effort and harmony of action. As at present conducted, the results of investigation at State stations are usually promulgated by publications which have a very limited distribution, and even where work in a single State is of a character which makes its conclusions generally applicable, the country at large fails to derive any benefit therefrom.

National legislation has been proposed to extend the work of experimental agriculture, establishing it in every State, as well as to strengthen that already in progress, and to make the results of all available to the country at large. Without interfering with the organization and management of State stations, whether at colleges or independent, Federal support may supplement existing agencies, and provide through this Department a certain degree of control to secure co-operation where needed and furnish such a medium of intercommunication and exchange as to greatly facilitate and improve the work as a whole.

I referred in a previous report to a convention of delegates from these various colleges and stations, called by me, to develop a system to unify results and make these institutions of greater benefit to the country. While waiting upon Congress for authority and means to execute the design and unanimously expressed wish of these institutions, which subject I heartily commend as worthy of careful consideration, I have commissioned a special agent to visit and inspect experiment stations, in order to ascertain what facilities already exist in this country for systematic experimentation, what has been actually accomplished, and especially what are the needs for future work. Many data have been collected, and will form the basis of a future report upon the subject.

There can be no question of the value of these investigations and experiments if liberally supported and ably conducted, especially in adjusting to its new conditions the agriculture dependent upon the

worn land of the Northern, Eastern, and Southern States. The benefit to be derived from them is practically limited only by the outlay which it is possible to make. The stations and colleges of the several States are constantly urged to enlarged experimentation, beyond present resources, and often find themselves "striking new leads," which they cannot follow, all for want of means. In nearly all cases there is land enough, and to spare, owned and immediately available. In numerous instances buildings are ample, or in shape to be easily converted to furnish the necessary accommodations for laboratories, stables, storage, and offices. But, as already shown, the current expense of experiment work, comprehensive and thorough, is very heavy. Cheap labor and appliances will not do. Salaries must be sufficient to command scientific ability of the first order, and the workers must be untrammeled by other duties. None of the colleges have the means to keep up their educational facilities and assume new obligations of this extent and character, however well recognized the importance of the work. A few of the States can be induced to make special provision sufficient for the purpose. Where State stations do exist and colleges have begun such work, it is apparent that further provision is necessary for their full development. Hence the very general interest in the bill now before Congress "for the establishment of agricultural experiment stations in connection with the agricultural colleges of the respective States and appropriating money therefor," and the prevalent opinion of its importance and the desire for its early enactment. No measure is now pending or proposed of greater import or bearing a brighter promise of deep-seated and lasting benefits to the agricultural interests of the United States in all their branches.

This bill is not, however, free from defects, and certain amendments may well be recommended here. The amount which it proposes to annually appropriate to each State ($15,000) is none too much to establish and maintain one good station. To permit this to be divided and appropriated among different stations or institutions would at once defeat the desired object; and instead of one strong station in every State, two or three worthless starvelings would here and there be found, consuming their whole allowance in the general expenses necessary to every station, with no margin for accomplishing results. Congress should not repeat the mistake which has already been made in one State at least, by which a land grant has been so divided up that no piece can be found big enough to be serviceable, or maintain an institution worthy the name of "State Agricultural College." But while every State should be required to keep the allowance intact and assign it for expenditure to one and only one place, permission should be granted for every State to determine by its legislature, and once for all, to what institution the appropriation shall be assigned. States having well-established independent

stations would doubtless prefer to strengthen them rather than create duplicates, and should be allowed by the law to do so; and it is certainly to be hoped that in States where the agricultural-college funds from the land grant of 1862 have been absorbed by institutions which have shown no desire to conform to the spirit of that law, the people will not permit their legislators to repeat the former blunder, but require them to create a bona-fide station, regardless of the merely nominal agricultural college existing. The bill as drawn allows only one-fifth ($3,000) of the first year's appropriation to be expended for buildings, repairs, &c., and only $750 annually thereafter. Considering the necessary expenses, especially in starting a station where nothing of the kind exists, this allowance is quite inadequate, and the restriction might defeat the object of the law. For buildings and repairs $5,000 should be allowed the first year and the second, and at least $1,000 annually thereafter. The buildings of the Massachusetts station, neither extravagant nor large, cost a good deal over $10,000, and, although models of their kind, and sufficient for the present income, would have to be enlarged with the extended operations made possible by the proposed Federal endowment. These and minor amendments are desirable, but the principle of the pending bill is right, and all friends of agricultural progress in America should unite in urging its passage.

With an agricultural-experiment station in every State, well equipped, ably managed, and liberally supported, the work would be still incomplete. To prevent useless and wasteful duplications and repetitions, and to secure co-operation and concerted action when needed, there must be a central station or office, and the natural place for this is at Washington. The center for the work should not, and indeed could not, dictate or control the operations of the State stations, but it could and should be of great service in harmonizing, unifying, and economizing the whole. If such central office did nothing more than serve as a medium of communication between the State stations—a sort of clearing-house, keeping every one informed as to the operations, progress, and results of all the others—it would still be indispensable, and a station of equal importance with the others. But, in addition, the central station should receive, criticise, digest, edit, and consolidate the results obtained at the various stations, and periodically promulgate the same in a form suited to popular understanding and application.

The "experiment-station bill" before Congress provided but partially for this important service to be performed at the Department of Agriculture. A vital omission is the failure to make special appropriation for the purpose. The already overtaxed clerical force of this constantly growing Department could not properly perform this additional duty. A new office or division is necessary, with a chief equal in ability to the directors of the State stations, and competent

assistants. This should be provided for independent of the regular appropriation for the Department; and the simplest and best way is to amend the pending bill, by placing the United States Department of Agriculture on an equal footing with the several States as to appropriations and general objects, but especially charging it with the duties indicated as belonging to the central station.

Experimental agriculture, upon a scientific basis, has already been so well begun in America, these efforts and their results have been so favorably received, and the facilities for an extension of the work are so good, if only the necessary funds can be obtained, that there is every reason for expecting immediate and lasting results from the early passage by Congress of the proposed law. The result would be a great impetus to experimental inquiry, and, in the words of another, "by providing the means for more and extended investigations, agriculture will be materially advanced, the condition of the farmer improved, and the agricultural calling accorded in public estimation some measure of that dignity and importance to which, as one of the chief elements in national wealth and greatness, it is fairly entitled." It is hoped the importance of this subject and the merits of the proposed legislation will commend themselves to the support of Congress.

THE BUREAU OF ANIMAL INDUSTRY.

The most important work of this bureau has been the investigation and control of the contagious diseases of animals. Our vast areas of productive pasture lands, our enormous crops of grain, and our salubrious climate have led to a most remarkable development of the flocks and herds of the country. With this increase in the number of animals, their constant importation, and free movement between all parts of the country contagious diseases have been introduced and disseminated to an alarming extent.

Most important at this time is the contagious pleuro-pneumonia of cattle, which, introduced into our Atlantic seaboard States nearly half a century ago, has until recently been kept away from the great central markets of the country. About three years ago the contagion of this disease was carried to Ohio, from Ohio to Illinois, and from Illinois to Kentucky and Missouri. After a continued application of all the authority granted under the national and State laws the plague was extirpated from Ohio, Missouri, and Kentucky, and it was thought to be also eradicated from Illinois. Unfortunately it was again found to be in existence in and around Chicago in September last. A thorough investigation has shown that the contagion has been disseminated among the cattle in the distillery stables and among those running at large on the streets and commons of the city and suburbs. Many animals have been exposed. The exact number is not known, but it is certainly very large, and, what is equally serious, the unfenced lands about the city have been infected.

Every effort possible under existing laws has been made to locate the diseased animals and isolate all that have been exposed. With such a plague as this existing in the greatest live-stock center of the country, threatening to impair both the quantity and quality of our food supply, and increasing the insecurity of our export trade in live cattle and in cattle products, it would have been most fortunate if every animal exposed to the disease and liable to contract it could have been summarily slaughtered and the contagion thus eradicated. The experience of all countries has been that the malady may be thoroughly and completely stamped out in this way, and that there is no other means by which the bovine species can be protected from its ravages. This disease is one of the most destructive which affects domesticated animals; it does not run a definite course and disappear, but remains in the same herd year after year, and as it frequently assumes a chronic form, there is a more than ordinary temptation to dispose of the milk and flesh of diseased animals for human food.

With a disease of this character at Chicago it has been truly said that the cattle industry of this country has reached a crisis. There can be no doubt that it will be soon and widely disseminated unless prompt and effectual action can be instituted for its speedy suppression. Even now it may have been scattered to some extent in the West, and the investigations of the next year will probably bring other outbreaks to light. The matter is a most important one, overshadowing in urgency all others affecting our agricultural population, and of vital interest also to every consumer of beef, of milk, of butter, and of cheese. To prevent the spread of this scourge, which has already greatly affected our foreign and inter-State commerce, additional legislation by Congress is now essential.

Under the authority conferred by the acts approved May 29, 1884, and June 30, 1886, the Department has co-operated with such States as accepted its rules and regulations for controlling and extirpating this disease. Much valuable work has already been done in Maryland, and the danger of the dissemination of the contagion from that State has been greatly lessened. No work has been done in the State of New York, because it was evident that the appropriation was not sufficient to secure any favorable results there on account of the extent of the infection. The disease also exists in New Jersey, Pennsylvania, and Virginia, but the State authorities have not yet accepted the rules and regulations of the Department for co-operation.

I greatly regret the necessity of announcing the existence of this dangerous disease over such a wide area, but the serious results to be apprehended from it make it imperative that the truth should be known, in order that such legislative action may be taken as is indicated by the emergency.

Of next importance among the contagious diseases of animals is the plague of swine, generally known as hog cholera. The losses from

this malady are estimated at from ten to thirty millions of dollars annually. The investigations of the past year have thrown much light upon its nature and cause; they will make possible more intelligent measures of prevention, and it is hoped that they will soon lead to discoveries which will enable our farmers to guard with more certainty against it.

In former years the introduction into the herds of our Middle and Northern States of the Texas or splenic fever of the South has caused the loss of many cattle during the hot and dry weather of summer and fall. The information which this Department has collected and disseminated in regard to the nature of this disease and the districts from which it might be introduced has enabled our stock men to protect themselves so effectually against it that the losses of the current year have been inconsiderable.

The quarantine of cattle imported from other countries has been maintained by this Department, and during the year no cases of contagious disease have been detected among such animals.

DIVISION OF CHEMISTRY.

The work in this division during the past year has been of a varied character. The usual number of examinations of waters, minerals, fertilizers, and miscellaneous articles has been made. This class of miscellaneous work is sufficient to employ the time of one analyst constantly.

The systematic work of the division has been directed to the following investigation, viz:

(1) *Dairy products.*—A critical examination has been made of the various methods of analysis which have been proposed for butter and milk. This study was considered of especial importance on account of the interest excited among the agriculturists of the country on the subject of artificial butter. Combined with the chemical examination there was made a thorough optical study of the various fats used in the fabrication of butter and mixtures of the same. As a result of these studies the best and most certain methods of distinguishing between pure and artificial butter have been pointed out.

A thorough study of the specific gravities of the different fats and oils has also been made, and in addition to this a new and accurate method of determining their melting points has been worked out.

In respect of milk, all the latest methods of analysis have been subjected to minute examination, and a new method of separating cream for analytical determination has been devised and put into successful operation. By this method the speedy and accurate estimation of the percentage of fat in milk has been secured. The results of all the work with dairy products have been collected, and will appear in Bulletin No. 14.

(2) *Condiments.*—It has long been known that spices, peppers, and

other condiments exposed for sale have been largely adulterated. To determine the character and extent of this adulteration the division has undertaken a critical chemical and microscopic study of these substances. The results of these studies, now ready for publication, show that the expectation of adulteration has, unhappily, not been disappointed, and also the nature of the adulterants used and the chemical and microscopic manipulation necessary for their detection.

(3) *Commercial fertilizers.*—The importance of accurate and uniform methods for the analysis of commercial fertilizers has long been acknowledged.

Accepting the invitation of the Department, the Association of Official Agricultural Chemists held its third annual convention in the rooms of the division, under the presidency of the chief Chemist. Representatives were present from the experimental stations and agricultural colleges of the country, and nearly all the State chemists were in attendance. Uniform methods of analysis were adopted, and the details of the manipulations have been published as Bulletin No. 12 of the division.

(4) *Experiments in the manufacture of sugar.*—As a result of the experiments carried on last year at Ottawa, Kansas, an account of which was published in Bulletin No. 6, the Department was led to continue the experiments at Fort Scott, Kansas.

Congress made a liberal appropriation for continuing these experiments, and the work of preparation was at once commenced on the approval of the bill, June 30, 1886. As a preliminary study the Chemist of the Department had made a careful examination of the various forms of machinery best adapted to the work, and a description of this machinery was published as Bulletin No. 8. The machinery for the experimental work was mostly constructed by the Pusey and Jones Company, of Wilmington, Delaware, and it was erected in a building provided by the Parkinson Sugar Company, at Fort Scott, Kansas. It was only in the latter part of September that this machinery was finally put into tolerable working order. All the mechanical difficulties which the experiments at Ottawa had revealed were avoided in the new machinery with the exception of the apparatus for moving the chips and slicing the cane, which, by neglect of the contractor, was left just as it was used at Ottawa. This omission caused a great deal of delay in the subsequent experiments.

The result of the season's work showed that the extraction of the sugar from the chipped cane proceeded with ease and to a degree wholly satisfactory. Less than one-half of 1 per cent. of total sugars out of the average 12 per cent. present was lost in the process of extraction. A severe frost September 30 greatly injured the cane and diminished the percentage of crystallizable sugar therein so rapidly, that on the 22d of October no further crystallization could be ob-

tained. While the experiments showed that the process of diffusion would practically secure all the sugar in the cane, they also showed that a good article of sirup could not be produced unless the canes were more thoroughly cleaned. This part of the work must be submitted to further experiment, which the early close of the manufacturing season unfortunately prevented.

Another difficulty of a chemical nature also presented itself during the progress of the work, and so far no practical method of avoiding it has been discovered. This is the inversion which the sucrose suffers during the progress of diffusion, and which is caused by the acids of the cane. These acids existed in remarkably large quantities in the cane used for experiments, and caused the conversion of a great deal of the crystallizable into uncrystallizable sugar. This diminished the product of the sugar and correspondingly increased the output of molasses. Experiments were made looking to the avoidance of this difficulty by making the water of diffusion alkaline. These, however, were not practically successful. Better results were obtained by using the carbonate of lime freshly precipitated or in the state of an impalpable powder, like powdered chalk. With the exception above mentioned the experiments were attended with encouraging results.

(5) *Experiments with sugar-cane from Louisiana.*—These experiments were undertaken as preliminary to the work which the Department proposes to do in Louisiana next year. About 150 tons of cane were sent by Hon. E. J. Gay, and the experiments were made during the first half of November. The most brilliant success attended these experiments, some 40 pounds per ton of sugar being obtained above the results obtained in Louisiana by the average milling.

These experiments prove beyond a doubt the easy applicability of diffusion and carbonatation or some similar process to the extraction of sugar from sugar-cane. By the introduction of this procedure into Louisiana the yield of sugar would be increased fully one-third over its present amount from a given weight of cane.

ENTOMOLOGICAL DIVISION.

The value of the work of this division was set forth in my last report to you, and is so well known to the farming and industrial community as to call for no comment. The appreciation of the work, however, is not confined to this country, and I observe with some pride the favor with which the publications of this division are received in other countries, as evidenced by letters of acknowledgment sent to me and by honors conferred upon the Entomologist. A marked evidence of the importance now attached to applied entomology abroad is shown in the appointment of a government entomologist for England, and in the holding on the Continent of an international exhi-

bition of machinery and contrivances for applied remedies against both fungi and insects that are destructive to cultivated plants. This congress was held in October at Florence, and his excellency B. Grimaldi, the minister of agriculture, industry, and commerce for Italy, very strongly urged me to have a representation of the discoveries and mechanical appliances that have been developed in the work of this division, and to send a representative to take part in the discussions of the congress to be held in connection with the exhibition. The Entomologist was, in fact, appointed one of the jurors. An intelligent report of these appliances and tests would have been of great value to this country, particularly as the more important devices, so far as I can learn, are modifications of those which have been perfected in this Department. The last year's appropriation for the work of the Entomological Division expressly prevents my taking advantage of any such opportunity in a foreign country, and I am, unfortunately, powerless to meet such emergency.

Ten thousand dollars of the appropriations to the division were transferred to the new Division of Ornithology and Mammalogy, and this has necessitated a reduction of the working force of the Entomologist. Although the possibilities for extended results are lessened thereby, the division has accomplished much good work during the year.

The publications of the division have been, in addition to the annual report of the Entomologist, the fourth report of the United States Entomological Commission, Bulletins Nos. 9, 11, and 12, and a complete report on insects affecting the orange.

The first-named work comprises the final report on the cotton-worm and the boll-worm, by Prof. C. V. Riley. It is a volume of more than 500 pages, and is illustrated by 64 plates in addition to the text figures. There has been a large call for this volume from cotton planters throughout the South, and it was fortunately published, after much delay, at the beginning of a season in which the cotton-worm appeared in great force in several of the cotton States. Bulletin No. 9 is a thoroughly revised edition of the manual of instructions in silk culture, introducing many new figures and modifying the work in the light of recent discoveries and methods. Bulletin No. 11 contains detailed reports of experiments made by agents of the division in New Jersey, Indiana, and Iowa, with many of the insecticides recommended against insects injurious to garden crops. Bulletin No. 12 comprises a long series of notes on the injurious insects of the season of 1885, an article on the production and manufacture of buhach, the California insecticide, a continuance of the work on forest insects, and additional material on the periodical cicada.

The report on insects affecting the orange has met with much favor among orange growers, and, although issued late in March, the edition is already exhausted. The remedies recommended have come into

quite general use, and there is still a continual demand for the report, a new edition of which I hope may soon be issued.

Several new and important investigations have been entered upon. The cottony cushion scale insect has for many years done great damage to orange, lemon, olive, and other fruit trees in California, into which State it was introduced nearly twenty years ago from Australia, while many other scale insects seriously affect California horticulture. In consequence, two agents were sent to Los Angeles early in the spring, and have continued through the summer, making an extensive series of experiments with remedies.

At the request of many prominent planters of the Lower Mississippi Valley an investigation has been begun into the habits of and remedies for the Southern buffalo-gnat, an insect which almost annually, and particularly in seasons of overflow, causes great loss of life among stock in that region. Three agents have visited infested localities at different times during the season, and the life history of the insect has been made out and will shortly be published. An investigation has also been begun upon the insects affecting garden crops in Florida; and agents in Ohio, Indiana, Iowa, Missouri, and Nebraska are studying the insects of their respective regions and experimenting with remedies.

The correspondence on economic entomology has been more extended than ever, and nearly three thousand letters of inquiry have been answered. This increase is due not only to the fact that agriculturists take a constantly increasing interest in the work of the division, but also to the fact that the season has been particularly favorable to the increase of many of our most injurious insects. The chinch-bug and the Hessian-fly have done considerable damage in several of the Western grain-growing States. Plant lice of all kinds have increased enormously, particularly in the Northeast. The hop-plant louse alone has damaged the hop crop of New York State to the extent of hundreds of thousands of dollars. The Entomologist visited the hop fields in September and made a number of important observations, which will lead to practical results. The shade trees of the principal cities of the Atlantic coast have suffered severely from the attacks of the fall web-worm and other hairy caterpillars, which the English sparrow will not touch. The work of this insect was especially noticeable at the capital on the avenues of trees, which form such a beautiful feature of the city. The Department has already published, as one of the bulletins of the Entomological Division, full directions how to protect trees from injury of this kind, and it is to be regretted that the District commissioners were not in a position to follow the practical recommendations thus made.

Work has been continued at the apicultural station in Illinois, and some valuable results accomplished. Most improvement in bee culture in the past has been in the direction of mechanical appliances

intended to economize wax, increase the honey supply, and facilitate manipulation. The experiments now being carried on have in view rather the improvement of the bee itself, and there is every promise that, by controlling reproduction and by other methods, the honey-yielding power of the bee can be materially increased, and that bee culture will thus receive an impetus analogous to that given to the dairy interest by improving the milk and butter producing qualities of the cow.

SILK.

I am happy to say that Congress at the last session met several of the recommendations and suggestions in my first annual report, and prominent among those departures which the Department has thus been able to make during the year may be mentioned that of experiments in reeling silk in this District from domestic-grown cocoons. Experiments had been made for many years in this country in the production of cocoons, and while the results were encouraging and progressive, yet our people, not having the incentive of a market to bring to the problem of successful cocoon raising, American genius and adaptability cannot be said to have become first-class cocoon raisers. Obviously, then, the step of wisdom, of economy, of prudence, must be one looking toward a profit in the production of cocoons, or, in other words, a market for them. There can be no doubt of our ability to raise cocoons, and that, too, by the labor of women and children, who might otherwise be unemployed.

Having, then, American-grown cocoons, what is their place in the economies? Will they furnish raw silk to be reeled in America in an American way, and furnish a remunerative reward to American labor?

The Entomologist considered this in his last report, and clearly showed that no decisive answer to this question could be reached until a practical silk-reel had been thoroughly tested at some point where the details of its work could be watched and directed by himself and his assistants, and where the work could be carried on for at least two years on strictly business principles. In accordance with this suggestion circulars have been sent into every section, offering to purchase cocoons, which, upon receipt, are appraised by experts at their market value. The experimental and reeling stations at San Francisco, New Orleans, and Philadelphia have been abandoned, and a careful experiment is now being made with the Serrell automatic reel at this Department. The success already obtained is most gratifying. This interesting experiment is enabling the Department to carefully note the quality of cocoons grown in different sections and climates, to examine the raw silk produced thereby, and to ascertain its market value; to compare the relative merits of osage-orange and mulberry fed worms; and to determine various other questions of importance

before any recommendation can be made. It is believed that in one respect an interesting fact has already been developed, viz., that silk produced from osage-orange-fed worms is in every way equal, and in some respects superior, to that produced from mulberry-fed worms, both in quality and quantity. The general result of these experiments is, indeed, so satisfactory, that I have asked Congress to increase the appropriation for the coming year by adding the $5,000 given to the Women's Silk-Culture Association of Philadelphia, which, though appropriated in connection with the appropriations of this Department, is virtually in the nature of a gift, over which I have no control, the association being neither responsible to me nor to any one else for the disbursement of the same.

DIVISION OF STATISTICS.

This branch of the Department organization has a corps of correspondents, representing over 2,300 counties, four in each county, a duplicate service for unification and special investigation, under the direction of State statistical agents, and a European statistical agent connected with the United States consular system.

Its work receives high commendation from the press of this country and unstinted praise from foreign publicists for the prompt and intelligent effort to keep abreast of the statistical progress of the age, to improve its machinery of crop reporting, to advance its standard of accuracy, to enlarge its practical utilities, and to assist in broadening the scope and unifying the methods of international statistics.

Its service is called in requisition by every branch of the Government, by the representatives of foreign courts, by home and foreign agricultural and industrial organizations, by writers and compilers, the representatives of commercial guilds, and the people generally. Its printed reports of the year, in which the utmost brevity has been sought, comprise nearly one thousand pages, in addition to its extensive manuscript reports, statements, and correspondence.

This division is becoming yearly a more efficient defense of producers against the speculative commercial class, who are unscrupulous in their selfish statements of the amount of production. The saving to farmers of a single mill on each bushel of grain amounts to nearly $3,000,000 per annum. The possibilities in protection of producers are enormous, and the accomplished results are believed to be very considerable. It has also done good service during the past year in collecting information exposing the numerous organized efforts to defraud the agricultural class on cunningly devised pretexts. From the isolation of farmers, and the large numbers of foreign birth little acquainted with the English language, a wide field is opened for the operation of sharpers and confidence-men.

The work of this division is not only various, but widely extended; not only continental, but international; claiming the attention and affecting the interests of producers and consumers, buyers and sellers, throughout the world. Its investigation becomes an indispensable adjunct to law-making, as well as to crop-growing, commercial distribution, and the daily economy of national life and labor. It is important, therefore, that it should possess all necessary facilities for the thorough and full exercise of its proper functions through the appreciation and aid of Congress.

Its international aspects are attested by the large increase of foreign correspondence and frequent interchange of cablegrams relative to the results of its work. It is called upon especially to assist in improving the methods of administrative statistics, relative to which an energetic effort is now in progress in connection with the governmental bureaus of statistics of the most advanced nations of the world. To this end, and for progress also in scientific statistics, an organization was effected in 1885 of the International Statistical Institute. Its headquarters is in London, and its membership already includes 57 statisticians of various countries, of whom 6 are citizens of this country. It seeks, among other important objects, a greater "uniformity in the methods of compiling and abstracting statistical returns," with a view to a comparison of results obtained in different countries. The first bicennial congress of these statisticians meets in Europe the coming year, and the participation of this Department in the important work is desired and expected.

The increase of production, as shown by statistics, has been marvelous in recent years. While the number of the people in 1880 was more than double that of 1850, the production of cereals not only kept pace with population, but furnished 53 bushels for each inhabitant in place of 38 at the earlier date. With an increase of seven millions of people in the first half of the present decade, the aggregate of cereals exceeded 3,000,000,000 bushels in 1885, still keeping up the extraordinary rate of supply attained in 1880, and showing in wheat a product five times as large as in 1850, and a corn crop nearly four times as large. The present year is one of medium productiveness, with less corn and more wheat than in 1885, promising nearly 1,700,000,000 bushels of corn, and something more than 450,000,000 bushels of wheat, a supply of the latter ample for consumption, while reserving a fourth of the whole for exportation. The other cereals have a medium rate of yield, the hay crop is ample, and the cotton product promises to be nearly as large as that of last year—six and a third to six and a half million bales.

The recent extension of area and product has been remarkable, as

shown by a comparison of the averages of the decade between 1870 and 1880 and those of the six years of the present decade, as follows:

Cereal.	1870-1879.		1880-1885.	
	Acres.	Bushels.	Acres.	Bushels.
Corn	43,741,331	1,184,486,954	67,225,872	1,635,357,756
Wheat	25,187,414	312,152,728	37,147,276	446,163,098
Oats	11,076,822	314,441,178	19,320,630	517,826,065
Rye	1,305,061	18,460,985	2,095,438	25,610,067
Barley	1,529,357	33,704,652	2,300,021	50,829,950
Buckwheat	551,104	9,747,272	858,313	11,089,007
All cereals	83,391,089	1,872,993,769	128,947,550	2,686,875,943

The increase of production in this brief period is over 43 per cent., while the enlargement of area is still greater, amounting to 54 per cent. So the advance was attained in a series of years with a comparatively low rate of yield, including the unfavorable seasons of 1881 and 1883.

The increase of wheat is seen to be more rapid than the increase of population, while the market for the surplus has declined, in consequence of the better harvests of other countries and of the increased facilities for handling the surplus of India and South America. The increase of grain-growing in South America comes from a strong tendency of European emigration in that direction and a larger use of improved implements and machines. Should it continue, competition with our grain fields will be still more severe.

Accurate records of the progress and changes of production of minor crops as well as large products, and of changes in value as well, are of the first importance to rural economists, to guide in a wise distribution of crop areas and in the introduction of new crops to fill the gaps in consumption and reduce the areas of such crops as may have a surplus unprofitably large.

DIVISION OF GARDENS AND GROUNDS, HORTICULTURE, ETC.

One of the prominent duties of this division is the propagation and distribution of economic plants. The impression seems to prevail that all kinds of plants are freely distributed from the gardens, and, in consequence, unlimited demands are made, and requests for general collections of plants are of common occurrence—requests that would tax the capacity of the largest nursery establishment in the world to fill. The impracticability, to say nothing regarding the impropriety, of attempting to meet these extensive demands is so inconsistent with the intentions of Congress in regard to the functions of the Department as to be sufficient reason for its inability to meet such demands. In the propagation of plants for general distribution the line is strictly drawn between merely ornamental plants and those of strictly economic value. Distribution is therefore confined to the

latter class; and even with this limitation great discrimination is necessary to select for propagation only those species and varieties that are of special merit and such as promise to be of value to the country.

The demand for tropical and semi-tropical fruit-bearing plants has been very pressing for several years from the warmer regions of California and Florida. These demands are being met so far as the means of the Department will permit. Observation proves that the climatic conditions necessary for the profitable culture of tropical plants are confined to a very limited area in the United States. Of course there are many tropical plants which produce their crops as annuals, and which can be profitably cultivated over an extensive area—such as cotton—and which only require a comparatively brief tropical season for their maturity. But in the case of ligneous plants which are perennial in their nature, the cold portion of the year, although of short duration, is still sufficiently severe to permanently injure them. The limits, therefore, of climate congenial to the growth of the vanilla bean, the chocolate plant or cacao, the coca, erythroscylon coca, coffee, cinnamon, nutmeg, pepper, cinchona, &c., are not yet defined. In localities where, owing to a series of congenial seasons, success seemed certain, an unusually cold period has destroyed all hopes; but this partial success is sufficient to encourage further attempts, although it would seem that such experiences would tend towards a different conclusion.

With regard to plants of a semi-tropical nature, such as the citrus family, experience proves that, under favorable conditions of position and culture, the coldest seasons likely to pertain in orange-growing regions are comparatively harmless to these crops, thus giving the industry a factor of permanency greatly in its favor.

The Department continues to foster industries of this kind by introducing new varieties and testing and disseminating the plants.

BOTANICAL DIVISION.

During the past year the work of the Botanical Division has been conducted with good success. Large and important additions have been made to the herbarium, which is constantly becoming more valuable as a representation of the flora of North America. In order to facilitate an acquaintance with the grasses of the country, a distribution of typical specimens has been made to twenty or more of the agricultural colleges and experiment stations and other educational institutions.

The subject of suitable grasses for cultivation in different climates, soils, and conditions is receiving attention from other countries as well as our own, and frequent applications from abroad are received for seeds of our native grasses for the purpose of experimental cultivation. One such application has been received from the government botanic garden in Upper India, where extensive tracts of saline

soil called "Usar land" exist. These tracts are uncultivated, and an attempt is being made to procure grasses suitable for cultivation on them.

We have complied with these requests so far as possible, but the difficulty of procuring seeds in distant localities has much restricted our distribution. Packages of the seeds of about thirty native species were sent to the different agricultural colleges and experiment stations for trial, and these were also sown in our own grounds, where most are growing and giving promise of usefulness.

Under my direction the Botanist has spent several weeks of this season in an examination of the native grasses of the arid regions of the West. This is but a beginning in this important work, and it will be resumed as soon as circumstances will permit.

The eastern limit which has been usually fixed as the beginning of the arid regions is the one hundredth meridian. It is said that nearly half of the public domain, exclusive of Alaska, lies west of this line, and amounts to some 900,000,000 acres.

Much the larger part of this immense region consists of mountains and arid plains. A large part of the land on the Pacific coast is productive without irrigation, and some of the finest lands for grazing purposes lie in the mountain valleys and parks where there is an abundant rainfall.

The remainder of this great domain west of the line above mentioned consists mainly of arid land, such as the high mesas of New Mexico, Western Texas, Arizona, and Southern California, together with the interior plains of Utah, Nevada, and Wyoming, in addition to those of Western Nebraska, Western Kansas, and Eastern Colorado.

Various estimates have been made as to the amount of this arid land. Its various portions present great variations in the amount of vegetation, and especially of the native grasses which they present, and consequently they vary accordingly in their capability for the support of cattle and sheep, for which purpose it was thought this land was alone adapted.

There is reason to believe that the unproductive character of a part of this region, notably that of Western Nebraska, Western Kansas, and Eastern Colorado, has been greatly exaggerated, and those sections have recently been the seat of a great rush of immigration, by which the larger portion of the district will be absorbed by homestead and pre-emption claims for the purpose of general cultivation. The efforts at agriculture which have been made in this region during the past two or three years have been attended with considerable success, possibly owing to favorable seasons, but the most sanguine expectations are entertained by the settlers.

Sufficient time has not elapsed to determine what may be the ultimate success of general agriculture, but there can be no doubt that the country is eminently adapted to pastoral purposes, and that the

cultivation of the soil and the selection of suitable kinds of grasses will double the capability of that country for the raising of stock and for dairying purposes. There can be little doubt that in the area above referred to there are 50,000 square miles capable of being utilized without irrigation, and capable of sustaining, under proper management, at least 50 head of cattle to the square mile, or 2,500,000 cattle on the entire tract. By many of the residents this estimate would be considered much too small; but it must be remembered that this estimate is based on the cultivation of the soil, or of a large part of it, and not on its use under the ranch system.

It is probable that there are large areas of arid land where no agricultural improvement can be expected, and such areas will continue to be occupied as ranches for cattle and sheep. Notwithstanding the great development of the cattle industry during recent years, statistics show that the production of beef has not kept pace with the increase of population, and to supply the great demand for meat we will require not only the usual product of the ranches, but there is also an excellent opportunity of cattle farming where the additional labor and care will greatly increase the supply. The great and rapid expansion of the country will soon require the consideration of means to reclaim and utilize to the fullest extent all portions of the public territory.

The investigations by the Botanist of the native grasses of the arid plains has convinced him that there are other species than the prevailing ones which can be substituted for them with the result of greatly increasing the grass product. But they, as well as other grasses and forage plants, require to be subjected to careful and prolonged trials and experiments in order to obtain proof of their relative values under the different circumstances of soil, altitude, &c., there existing. These trials and experiments cannot well be made by individuals on account of the expense and peculiar skill required and the knowledge of the grasses and forage plants to be tested. Hence it is highly important that the Government should provide experimental stations at suitable points, particularly in the interest of that body of settlers who are now taking possession of the country, and who will, without the aid of such information as could thus be communicated, be exposed to many losses and disappointments in prosecuting agriculture under the peculiar circumstances there existing. As the result of these recent investigations I am led to particularly recommend what I consider to be a fine situation for an experimental grass station at the town of Wallace, in the extreme western part of Kansas. Here is the Government reservation of Fort Wallace, embracing a tract of 2 miles wide by 7 miles long, and including low or bottom land and high upland, and therefore eminently suitable for the enterprise. I regard the location as typical of the larger portion of that arid region. There are a number of buildings formerly used for

the military post which would answer all the purposes required, and a small stream runs through the reservation, supplying water for stock and some for irrigation. A very moderate appropriation, applied under the direction of this Department, could here be made productive of great good.

MYCOLOGICAL SECTION.

INVESTIGATIONS OF THE FUNGOUS DISEASES OF PLANTS.

The heavy losses sustained by the fruit-growers and farmers of the country on account of the mildews, blights, smuts, rusts, and other injurious fungi—losses amounting in the aggregate to many millions of dollars annually—very forcibly demonstrate the importance of thoroughly investigating the nature and habits of these destructive parasites, with the view of discovering means for preventing their ravages.

Early in my administration I found that the Department was in constant receipt of letters from agriculturists and fruit-growers in all parts of the country, earnestly asking for information on matters pertaining to this subject, and especially inquiring for remedies that will enable them to prevent or at least check the losses occasioned by these parasites.

Memorials from scientific societies have frequently been addressed to the Commissioner, setting forth the importance of the investigation of plant diseases, and strongly urging the establishing in the Department of a division to be wholly devoted to this work.

Fully appreciating the value and importance of information on this subject, and understanding its intimate connection with the interests of horticulture and general agriculture, one of the first matters, therefore, to which I gave attention upon assuming the duties of Commissioner was this question of the fungous diseases of plants. In the absence of a specific appropriation for the prosecution of this work, the duties involved were assigned to the Assistant Botanist, a person fully qualified to conduct the required investigations, and whose appointment was made with this object in view.

Investigations were prosecuted with as much vigor as possible during the year, and among the important plant diseases that have been directly brought to the attention of the Department by correspondents during that time are pear blight, the fungous diseases of wheat and rice, corn smut, the smut of the smaller grains, strawberry rust, the red rust of the raspberry, raspberry-cane rust, leaf-spot disease of the raspberry, "double flowers" of blackberry, foot-rot of the orange tree, the nectria of orange twigs, orange-leaf scab, gooseberry blight, leaf-spot disease of the currant, black knot of the plum and cherry trees, apple-leaf scab and rust, the disease causing the cracking of pears and apples, peach yellows, peach-leaf curl, plum rot, potato scab, cotton rust, and the various fungous diseases of the grape.

These have all received as much attention as the time and means at command would allow. Concerning all the diseases here named there remains more to be learned than is now known. The life history of these disease-producing pests has for the greater part yet to be traced. Careful and long-continued observations, both in the field and laboratory, will be required to accomplish this, but such work is necessary if we wish to make intelligent application of remedies to combat these evils. We have to learn how these fungi are distributed, how they come upon or enter the plants they infest, what phases of development they pass through—phases often more complicated than the transformation of insects and far more difficult to trace; and, finally, how they maintain their existence during the season of winter. This work has been accomplished in only a very few cases.

From results obtained, however, and from other sources of information received during the administration of this branch of the Department, we may safely assume that the value of the corn and wheat annually destroyed in this country by diseases induced by fungi is not less than $200,000,000. The potato rot, so destructive in wet seasons, caused a loss in 1885, in the chief potato-growing States, of from 10 to 40 per cent. of the entire crop. The grape vine is particularly subject to the attacks of fungi. Scientists have described over 200 species found upon this plant alone. Some of these, as the mildew and black rot, are particularly destructive, so much so that grape-growing has ceased to be profitable in many localities once noted for their production of this fruit, and hundreds of acres of vineyards have been rooted out simply because of a lack of information respecting the nature and habits of these parasites and the means to be employed in preventing their ravages. The rust of the cotton plant is another fungous disease that causes incalculable loss to planters of the cotton-growing States. The orange interests in Florida are seriously threatened by the fungi that attack this tree, over 100 species of which have been figured and described by European mycologists. The apple tree has its peculiar and destructive parasites, and so have the pear, the peach, the plum, the quince; and so also have the small fruits, as the raspberry, blackberry, currant, and strawberry; nor are our garden vegetables, nor the plants we cultivate for ornament or shade, more exempt than others from the ravages of these diseases.

While this branch of investigation could not be prosecuted more than superficially, owing to the want of funds, yet it is gratifying to note that an encouraging result has followed.

During the early part of the present season circulars were distributed to all parts of the country, for the purpose of gaining a more exact knowledge of the range and extent of injury occasioned by the fungous diseases of the grape, and material was collected and plates of illustrations prepared for a special report on this interesting and important subject. Circulars were also sent out proposing for trial

certain remedies believed to be of value in combating the grape mildew and rot. The preparation of the report here referred to is now engaging the attention of the Mycologist.

In accordance with my recommendations to committees of Congress, a small appropriation was granted the Department for enlarging the scope of this investigation. This has enabled me to place the work in the immediate and full charge of a special agent, to procure such assistance as was imperatively necessary and to infuse vigor into the work.

A consideration of the above facts will satisfy the most casual observer that the field for labor is a large one and the difficulties connected with the work of investigation necessarily render it slow of results, but the great practical value of these results when attained will, I am sure, more than warrant the labor spent upon them. If, for example, through these investigations we learn how to effectually prevent the leaf rust of the cotton plant or the yellows of the peach, the value of such a result would be so much out of proportion to the aggregate of the entire annual appropriation made to the Department, that the latter would sink into insignificance.

I have submitted an estimate for the thorough prosecution of this labor, and I trust that the matter will receive its due consideration at the hands of Congress. That the agricultural public is interested in the work is amply attested by correspondence already at hand, and that it commends itself to the scientific thought of the country is proven by the following resolutions, which I beg leave to present.

At the meeting of the American Pomological Society at Grand Rapids, Michigan, it was unanimously resolved—

That this society heartily commends the action of Commissioner Colman, of the United States Department of Agriculture, in the appointment of a person to investigate the diseases of plants, and desires to assure him of continued support in his effort to develop this new line of work in the Department.

At the meeting of the Western New York Horticultural Society it was resolved—

That the Western New York Horticultural Society, believing that one of the pressing needs of the horticulturist is more reliable and complete information regarding the hosts of microscopic foes, especially parasitic fungi, which beset our cultivated plants, and which annually entail a loss to the country of many millions of dollars, desires to give to the Commissioner of Agriculture its hearty assurance of support in his efforts to build up a section of mycology which shall be suitably equipped for the difficult investigations that this subject demands.

The following was received from the Botanical Club of the American Association for the Advancement of Science:

The honorable COMMISSIONER OF AGRICULTURE:

The members of the Botanical Club of the American Association for the Advancement of Science, recognizing the importance of the movement so happily inaugurated by you whereby provision has been made for the investigation of plant diseases, would hereby assure you of their hearty support in all your efforts to procure the necessary means for carrying on the work proposed.

Finally, the practical issue of all these endeavors cannot fail to have its effect in all the ramifications of important branches of trade and commerce, and the subject is commended as worthy of the most careful deliberation.

FORESTRY.

I desire again to refer in strong terms to the urgent needs of the country for a changed forest policy and the requirements of the Department for a proper prosecution of needful investigations into the subject of forestry. While I have made only the usual estimate of $10,000 for the continuance of the division, I consider this amount below the actual requirements for a line of work which, if it is to be done at all under Government control, recommendation, or advice, should be pursued in a manner adequate to its importance to the nation at large.

While, from the experience of the Old World, we may learn the effects of recklessness and waste, and the necessity of a rational forest policy, yet with our different system of landholding we cannot expect to adopt their plans of administration. While from European forest management we may learn the principles underlying forest growth and forest management in general, with our different forest, flora, and different climatic conditions we shall have to work out our own systems of management. This requires painstaking and systematic study and inquiry at the hands of experts conversant with forestry principles and forest conditions. The Department should be placed in position to employ and pay liberally the very best talent on these subjects which the country affords.

Regarded simply from a business point of view, the forestry problem is growing every year in importance and urgency as the forest area is diminished by both legitimate and reckless denudation, and it should be an object of serious concern to the Government to insure continuity of supply of raw material to a lumber industry representing a capital invested of not less than $200,000,000, not to speak of the many minor necessities of a wood supply for railroad building, manufactures, and domestic purposes. Figures are at hand to prove that this supply must be waning.

Practically there is in the United States no forest reproduction attempted or forest planting done worth mentioning, in comparison with the enormous annual consumption of forest products.

Of still more momentous bearing upon the welfare of the country are the effects upon climatic and agricultural conditions caused by improper deforestation.

The influence of the forest cover on water supply has become especially noticeable in those districts which, like Eastern Colorado and Southern California, are dependent for their agricultural success upon irrigation, and where a diminution and irregularity of the wonted

water supply has gone hand in hand with the havoc and desolation wrought in the mountains adjoining by reckless denudation.

The scientific data so far at hand to establish this inter-relation of forest cover and water supply will be reviewed and their application to the particular conditions of our own country discussed in a special report of the Forestry Division.

While, through publications from this Department and other sources, through agitation and discussion by societies and newspapers, a better knowledge of the condition of our forests has been gained, and through representations of the experience of older nations, the importance of the subject of forestry and the dangers resulting from its neglect are appreciated by a larger number of people than formerly, yet it cannot be said that we have come very much nearer to a practical solution of the problem. Meanwhile the difficulties in its solution are increasing as time goes on.

As a first step of reform undoubtedly the land policy of the United States in the timbered regions requires a change according to the changed conditions of those localities. A state of affairs which allows railroad companies, miners, prospectors, and settlers to cut timber on the public domain as their wants require, without any proper supervision, without proper opportunity of acquiring either material or timber land by purchase, holds out a premium for fraud, theft, and immorality. The inadequacy of the force to prevent depredations and to enforce existing laws is productive of the most reckless devastation of these mountain forests, while the value of timber destroyed by fire in one year in Colorado alone would suffice to pay a force of a thousand forest guards.

Besides the good example which the Government may set in taking better care of its own timber lands, it might appropriately extend its operations, by planting on a large scale, in bodies of several contiguous sections, in the treeless States and Territories of the West.

The military reservations in those States, owned by the General Government, would form a most desirable field of operation. Only by such extensive planting can a desirable modification of the extremes of climate on the Western plains be expected.

If, as seems contemplated by Congress, the so-called timber-culture act should be repealed, I would suggest that this be not done without in some way making proper provision for timber planting on homestead entries. More good is to be expected from such planting, where the owner is near at hand to watch and give needed cultivation, than in the case of timber-claim planting, which, to a large extent, has been practiced, it is alleged, for mere speculative purposes.

The newly appointed chief of the division was sent by me to inspect the tree planting in Kansas and Nebraska, and his observations will enable me to give much needed information to the Western planter in regard to methods of forest planting.

The division, hitherto with entirely inadequate means for such work, has attempted mainly to gather statistics and compile data from home and foreign sources, with the purpose of ascertaining our actual forest conditions and requirements, and to acquaint our people with the significance and the importance of our forests, and by presenting the experiences of foreign nations and their methods of forest administration to awaken an interest in and to popularize the subject of forestry.

This class of work, which has been vigorously prosecuted during the year, will be brought to a close by a series of special reports, illustrating the relation of forestry to certain industries directly dependent on forest supplies and often involving large forest tracts; a fact which ought to dictate a more careful policy with regard to future supply. These are, notably, the railroad and mining companies, charcoal manufacturers, &c.

These reports have been written by experts, and, besides their general interest, will be of value to the particular industries to which they refer.

A new line of work has been begun during the year by the study of the biology of our most important timber trees. Before we can advise as to the treatment of a given species we must know its nature, life history, and behavior under various conditions. I am gratified at the willingness with which able botanists in various parts of the country have undertaken these special biological studies, which will eventually form the basis of future American forestry. A tabular classification of the economically important flora, manuals on willow culture, and other subjects directly bearing on American forest practice are in preparation.

To bring the educational institutions into sympathy with the forestry movement, and to interest them in forestry matters, the public school organizations of several States have been invited to co-operate in gathering the forestry statistics of their localities, and schedules for phenological observations have been distributed among the agricultural colleges and several thousand private observers.

The requirements of experimentation and distribution of seeds and seedlings, as provided in the appropriation bill for this division, could not be fulfilled at all, or only very partially, for lack of adequate funds.

The liability of tree seeds to deteriorate when kept, and the difficulty of handling most of them by inexperienced planters, makes this manner of supplying material a doubtful aid to tree planters. The distribution of seedlings, on the other hand, requires a more systematic and organized arrangement than the present funds of the division will allow.

Both the requirements of experimentation and aid by supply of material, as well as instruction in the art of forest planting and man-

agement, could be admirably complied with in connection with such plantations by the General Government, as heretofore suggested.

Several States, notably New York, Ohio, Colorado, and California, recognizing the value of their forests, have instituted commissions or boards of forestry, with a view of at least protecting what remains from useless destruction. Besides the National Forestry Congress, which continues in its deserving missionary work, several State forestry associations are endeavoring to create a public sentiment in the interest of forest preservation. These endeavors are worthy of encouragement, and this Department should be authorized in its discretion to extend aid to such boards of forestry and to societies by the publication of their proceedings or in other ways.

With the increasing interest in forestry the correspondence of a technical character is constantly growing, and this work of giving information and advice alone consumes a considerable amount of time, and requires better office facilities than it has been possible to provide without curtailing other work.

It will appear from these statements that the work of this division ought to grow in importance as well as in scope; but that, in order to do the work required for a country with such a vast area, such a great diversity of climate, soil, and conditions, such immense variety of forest flora, more adequate means must be provided, if it is to be more reliable, more exhaustive, and of more practical value, or a direct benefit to our people. If forethought is the root of statesmanship, here indeed is a worthy field for its exercise; for the interests of forestry lie in the future rather than in the present. It is for future generations rather than for our own that we must be wise in dealing with this problem, and the time for dealing with it is now, when favorable conditions are not yet entirely lost, and while it is still possible to avoid the disastrous effects of a policy of unconcern.

SEED DIVISION.

In the Seed Division much attention has been given to improved methods for handling, storing, ventilating, testing, and distributing the large quantity of seed received.

The detailed report of the division will show that, aside from the usual distribution to miscellaneous applicants, a regular system of distribution has been begun to experiment stations and agricultural colleges and to agricultural societies. In view of the fact of imperfect returns relative to the adaptation of new and valuable seeds to the various localities, I have prepared suitable circulars, asking for more definite and full information from the directors of experiment stations, agricultural colleges, State boards of agriculture, agricultural societies, and individuals who are interested in experimental work. The responses received at this date indicate that the plan will

be successful, and that valuable practical information will thus be secured for diffusion among the people.

Of the new and valuable seeds introduced from foreign countries, which have been distributed during the fiscal year ending June 30, some of which are likely to prove of great value to the agricultural interests, are several varieties of Russian forage plants and forest-tree seeds, and several of wheat from Southern, Central, and Northern Europe. Increased attention has been given to the distribution of native and foreign plants. An earnest and measurably successful effort has been made to distribute seeds in the special localities to which they are best adapted.

This Department is in receipt of numerous letters from the directors of agricultural experiment stations expressive of their satisfaction at the hearty co-operation now existing between the Department and themselves in regard to present system of distribution, by which they are the first to receive seeds of new and rare varieties, and of the good results to the country at large that will surely be realized therefrom.

Just cause of complaint has heretofore existed that the seeds designed for distribution in the Gulf States and California have been received at too late a date for the customary time of planting. To remedy this, the putting up of the seeds designed for general distribution has been begun at a much earlier date than usual, and sufficient additional storage has been provided for the seeds that are ready for mailing.

Recognizing the fact of the tendency to overcrop and exhaust the soil, and that comparatively little attention is paid by very many farmers to either the preservation of the fertility of the soil or to the proper care and selection of seed (both being direct causes of a continuously diminishing average yield), it becomes necessary, for the welfare of the nation, that the General Government, which is largely based on its agricultural resources, should lend its influence in remedying this evil, so far as it is possible, by the diffusion of information bearing upon these topics, as well as by the importation and interchange of seeds of a high grade of productiveness that will tend to increase the annual average yield.

To show the extent of the distribution of seeds alone and its possible value in increasing the total annual production, and indirectly the prosperity of the people, it may be stated that for the fiscal year ending June 30, 1886, there were sent out from this Department 4,267,165 packages of seeds, embracing vegetable, flower, field, textile, &c.

Another evidence of the improvements introduced into this division is the attention now given to the nature of the soils and the climatic differences and the better adaptation of the seeds to special localities, and also in the fact that every effort consistent with the

conditions still imposed upon me has been made to secure from those who receive the seeds more accurate and reliable reports as to their practical value to American farmers.

MICROSCOPICAL DIVISION.

The recent enactment of a United States law regulating the manufacture and sale of oleomargarine has operated to increase the work of this division. Many letters have been received and answered by the microscopist from scientific men, professors in colleges, universities, and experiment stations, as well as from editors of scientific and literary publications, and especially from those engaged in the dairy interests of the country, asking for such information as may be of value in relation to the best methods of detecting butter substitutes.

During the current year the division has made over one thousand examinations of pure butter, of butter substitutes, and of the fats of various animals. The Microscopist believes that every statement heretofore emanating from this division is amply confirmed by the results of his investigations during the present year relating to the crystallography of the fats of animals and plants, and particularly with regard to the views advanced in his former report, that the fats of various animals yield typical crystals, which may at once be distinguished from one another. In the production of these typical crystals the respective fats are subjected to a simple uniform treatment. While nearly all the fats are composed of palmatine, stearine, and oleine, they contain these glycerides in greatly varying proportions, and there may be other considerations, as yet unknown, which contribute to the remarkable diversity seen in the composite fats of different animals. Many specimens have been mounted and sent to the various agricultural colleges and experiment stations. A large number of photographs representing the diverse character of the typical fatty crystals have also been made and distributed to scientific men, the object being to demonstrate that the fat of one animal may be easily distinguished, within certain limits, from that of another. Over one thousand specimens of fats, including the butter of noted breeds and various compositions of oleomargarine, have been made during the current year and results noted.

Preliminary experiments have also been made in testing butter with relation to the effects of silo feed, grass feed, dry feed, &c. It is the opinion of the Microscopist that there are strong indications that within certain limits the butter crystals are affected as to their form and density by the breed and character of food.

Butter is being prepared at present by prominent dairymen and farmers of several States who have especially fine breeds of cattle with a view to having microscopic observations made in regard to this question. Photographs, exhibiting modifications of the butter

crystals under the varied conditions mentioned, will be employed to illustrate the subject in the annual report of the division.

This is believed to transcend in importance all others whose investigations have been imposed upon the division, and much study and time have therefore been devoted to it. As the investigations are completed the Microscopist will give his attention to the adulteration of other food supplies, as also to an examination of certain fibers, &c. The results of these will be embodied in a future report.

POMOLOGICAL DIVISION.

Another subject which I last year commended to your consideration has, I am glad to say, received that recognition from Congress which it has long deserved, and I have been enabled to establish during the year a Pomological Division in this Department.

The satisfaction of many leading thinkers with this departure has been generously expressed, not only through correspondence, but through offers of hearty co-operation in the methods employed to establish the division in a proper way. It is too early in the history of the division to enumerate definite results, but there is every prospect that, if properly encouraged, we shall be able to furnish the country, and especially its pomological and horticultural industries, with information of value. The United States contains some of the largest and best adapted fruit-producing regions of the world. Farmers everywhere are beginning to give thought to the necessity of diversification, and naturally a fruit orchard suggests itself as the fit successor of those crops which year after year have been exhausting his soil and lessening his annual profits more and more. The all-important step to the thoughtful farmer, then, is necessarily the first one. What can science and the latest results of experience and information teach him in the matter of adaptation of fruit trees to particular soils and climates? This is what the division will endeavor to undertake to set forth. Different pomological experimenters, as well as agricultural colleges, have generously offered their grounds and personal labors to assist in any experiments that may be instituted.

We may also make an investigation relative to foreign fruits, and the probability of their successful importation and development in American soil, to meet the demands of local markets; we may ascertain the habitat of every fruit now known, and in diverse ways assist an industry whose annual product probably represents a value of $150,000,000, and is an important one to the United States. Our people need to plant intelligently, as well as to reap intelligence through public schools, and it is just as much the province of the General Government to assist them in one as in the other. Horticulture is elevating in all its tendencies, and, by advancing and protecting and promoting this and other branches of agriculture, our

people will advance in those paths which will lead to moral and intellectual and prosperous citizenship.

DIVISION OF ECONOMIC ORNITHOLOGY AND MAMMALOGY.

The investigation of the economic relations of birds was begun July 1, 1885, as a branch of the Division of Entomology. On the 1st of July, 1886, pursuant to an act of the Forty-ninth Congress, the scope of the work was enlarged, and it was made an independent division, "for the promotion of economic ornithology and mammalogy, an investigation of the food habits, distribution, and migrations of North American birds and mammals in relation to agriculture, horticulture, and forestry."

The work of the division consists in the collection of facts relating to the above subjects, and in the preparation for distribution among farmers and others of special reports and bulletins upon birds and mammals which affect the interests of the farmer, and also upon the migration and distribution of North American species. In this way it is hoped to correct the present widespread ignorance concerning injurious and beneficial effects of our common birds and mammals, and to prevent the wholesale destruction of useful species now going on.

At the outset it was seen that two birds pre-eminently claimed the immediate attention of the division. The so-called English sparrow (*Passer domesticus*), and the bobolink, or rice-bird (*Dolichonyx oryzivorus*), by their numerical abundance, the extent of the damages they were said to cause at certain times of the year, and the widespread difference of opinion in regard to their economic status as a whole, demanded searching and systematic investigation; hence, they have been made subjects of special research.

THE ENGLISH SPARROW (*Passer domesticus.*)

Questions relating to the English sparrow were contained in the first circular on Economic Ornithology, issued by the Department (in July, 1885). Subsequently these questions were amplified, and during the current year a special circular and schedule were prepared, upwards of 5,000 copies of which have been distributed. To date replies have been received from about 2,500 persons. They contain a vast amount of valuable information, which is now being collated for publication. In order to be able in future years to determine the rate of spread of the sparrow over regions which it does not now occupy, the Department has undertaken to ascertain, with as much precision as possible, the exact limits of its distribution at the present time, and hopes to show the same by means of a colored map in its forthcoming bulletin on the sparrow question. In addition to the material collected by the Department of Agriculture, the American Ornithologists' Union has turned over to the division the

results of its investigations on the eligibility or ineligibility of the European house sparrow in America. This material has been since collated and arranged by Dr. F. H. Hoadley, who, from interest in the subject, kindly volunteered his services.

THE BOBOLINK, OR RICE-BIRD (*Dolichonyx oryzivorous*).

Early in the progress of the work it became apparent that, if any credence was to be placed on the testimony ofpersons interested, the bobolink, or rice-bird, must be regarded as one of the most destructive of birds. Hence a special circular to rice growers was prepared, and copies were sent to all planters whose addresses the division was able to secure. The replies received were so startling in the magnitude of the losses they revealed, that it was thought advisable to make a thorough study of the whole subject of rice culture, and to investigate on the spot the manner in which the ravages were committed, in the hope of devising some means, compatible with reasonable economy, for lessening their extent. With this object in view the Assistant Ornithologist, Dr. A. K. Fisher, was sent on an extended tour through the rice-growing districts of the Southern States, from Charleston to New Orleans. His investigations were carried on in the spring, at and shortly after the time of planting. At harvest-time in the fall the chief of the division, Dr. C. Hart Merriam, visited the rice fields of portions of South Carolina and Georgia, and witnessed in person the destructive ravages of the birds at the height of the season. Furthermore, to render the investigation still more complete, the Department has employed a special field agent, Col. Alexander Macbeth, whose headquarters are at Georgetown, South Carolina, in the very heart of one of the largest rice-growing districts. The results of these investigations will be given in full in the forthcoming report of the division.

The work of the division has not been limited to the study of the English sparrow and bobolink. Circulars of inquiry have been issued, and a large amount of information has been accumulated concerning the food habits of various birds and mammals, with special reference to those of decided economic importance. Among these may be mentioned the hawks and owls, the crow, the various blackbirds, the gophers, and the small mammals which prey upon poultry.

For the purpose of positively determining the exact character of the food habits of birds at different times of the year the division has made a collection of their gizzard and stomach contents. In this undertaking it has been aided by ornithologists throughout the country, many of whom have made large contributions, thus doubly utilizing birds killed for strictly scientific purposes.

From a scientific as well as a practical point of view the work here undertaken cannot fail to prove of great value, and I recommend a continuance of the encouragement which Congress has already given for the thorough study of this interesting subject.

LABORATORY.

I shall ask Congress at the forthcoming session to provide means for the erection of a new chemical laboratory, apart from the main building of the Department, in order that the latter and its occupants may be removed from the annoyance of offensive odors and dangers from combustion which now continually surround them. The present laboratory is now in the basement of the main building, in quarters illy fitted for the purpose, neither being fire-proof nor healthful. The building is of a highly inflammable character, and no better argument ought to be necessary. Indeed, within the past two weeks an explosion took place there which set a portion of the laboratory on fire. The flames were fed in every direction by chemicals and oils, and but for the timely forethought of an assistant the entire building would undoubtedly have been destroyed, together with books and records, whose loss would be incalculable. Congress should regard this warning and provide suitable and safe quarters for this, one of the most important divisions of the Department.

IRRIGATION.

Upon assuming my duties as Commissioner I found a comprehensive examination going on into the subject of irrigation. While it was necessarily abandoned for a time, I am glad to be able to report that I have since been able, though working with reduced appropriations, to complete this work, which must prove of unusual interest to those who can only successfully till the ground by means of this auxiliary force. Congress has already called for the manuscript, and it will be submitted at the opening of the session.

DAIRY.

The operations of the dairy branch of the Department have been continued during the year, and it has published a special report, which is being widely disseminated. It is hoped that the publication and distribution of this report will be sufficiently encouraging to those engaged in the dairy industry to induce them to continue to keep this branch of the Department informed of its condition and needs.

TOBACCO CULTURE.

At the request of a correspondent the Department undertook to secure, through the kindness of the State Department, specimens of tobacco leaf and tobacco seed, as well as short articles upon the cultivation of the crop, from every quarter where the plant is grown. The responses of the consuls have been generous and very satisfactory. The seed has been placed in the hands of careful cultivators with the view to improvement of our own seed, and the various articles received will be prepared for a forthcoming report.

THE GOVERNMENT TEA FARM.

A great deal has been said and written in recent years relative to the cultivation of the tea plant and the manufacture of its leaf into tea upon a practical and commercial basis. The Government has appropriated for the last eight years an aggregate of $28,000 to encourage the industry. With the desire to thoroughly test the question a so-called "tea farm" was leased some years ago by a predecessor, and a plantation of tea seed and young plants inaugurated. Active efforts in this direction were soon abandoned, and since that the farm has been used simply as a distributing center for those who wished the plants for trial. But it should be borne in mind that this farm was not established for the distribution of plants. The original design was to test there the culture of the plant and the manufacture of tea as a commercial and profitable enterprise. The Department had long previous to its establishment given its opinion that tea culture, so far as the plant was concerned, presented no cultural or climatic difficulty, and had encouraged the cultivation of the crop as a domestic industry. It had distributed plants for years with that view, and with that view only, believing that tea culture as a profitable and commercial industry could not be encouraged, because there could not be found any foundation to encourage capital to develop the enterprise. After these years, and at a considerable expense, the Department is confirmed in its original belief. Congress has provided for the closing out of the interests of the Government at its tea farm, and I can see no reason to doubt its wisdom. The farm will be abandoned and revert to its owner, according to the terms of the lease, with the beginning of the new fiscal year.

STORM AND FLOOD SIGNALS.

Petitions have been received at the Department for many years, and are still coming in, with relation to the establishment by the Government of a system of signaling by cannon, from central stations, to announce the approach of storm, flood, or frost. It seems to be the general belief among planters and farmers that such central stations could be established at the post-office or other place under Federal control, and that cannon and other field pieces belonging to the Government, now happily in disuse, could thus be utilized in the avocations of peace. The expense would be trifling when compared with the benefits to be derived in many sections.

I would recommend that a few stations be established, under the direction of the Chief Signal Officer, for the purpose of testing the plan proposed.

COTTON INDUSTRY.

In accordance with a recommendation of my last report, Congress has provided for the printing of a report of an elaborate investiga-

tion into the subject of American wool. This report is now in press, after several years' delay, and will soon be ready for distribution.

Pending the investigations incident to the preparation of this report experts and manufacturers became acquainted with the general character of the results embodied therein, and this knowledge produced a demand for similar information relative to cotton. In response to such demand from various sources the Department in 1883 and 1884 caused to be collected for investigation a series of samples, as follows:

(1) Cotton produced under different known conditions of seed, soil, climate, and culture in all parts of the great cotton belt of the United States.

(2) Representative cotton from the different commercial grades of the several cotton markets.

(3) Cotton from different stages in various processes of manufacture.

The material thus collected was to be used in the careful examination of the external characteristics—the length, fineness, strength, and elasticity—upon all of which the value of the staple evidently depends.

This examination was begun and carried along in connection with the final work of examination of wools, using the same apparatus and similar methods, and in all about $5,000 expended upon it. In view of the results thus far obtained and of those that may yet be secured, as well as of the expense already incurred, it seems eminently desirable that this investigation should be completed and the information developed published at once.

The information already obtained is voluminous, but I am sorry to say is incomplete, and cannot be published until a large number of tests are made. The work would no doubt be of inestimable value both to the producer and consumer of this important staple, and they are entitled to that benefit which was designed for them when the work was instituted. I am assured the investigation can be completed for $7,500, and I commend the proposition as worthy of consideration by Congress.

INVESTIGATIONS ABROAD.

I have referred in a former portion of this report to my inability to meet emergencies for specific investigations which naturally cannot be anticipated and the expense annually estimated. The Department is continually in receipt, through the State Department and other sources, of invitations and urgent requests for American representation at foreign exhibitions and enterprises of various kinds. The amount of information to be gleaned by the attendance of intelligent representatives and specialists at these various centers for observation and learning could be made of lasting benefit to our own

people. It ought to be borne in mind that the official reports, when there are such, are not written from an American point of view, and hence the practicability or impracticability of propositions or machinery as applied in this country is never set forth. The foundation of the prosperity of this country rests upon agriculture, and the greatest success of agriculture will come from an intelligent application of those practical methods which are the result of the combined thought and experience not of America, but of the world itself. Our people, competing as they do in foreign markets, ought to have the advantage of every avenue which promises the latest information relative to foreign needs and foreign methods. The information should be collated and compiled by the best of our specialists. Faint efforts have been made in the past to gather such information; and while the result has been more than commensurate with the expense incurred, yet there has always been the attending and humiliating embarrassment of a lack of funds, and the work therefore more or less circumscribed.

The Department has no recourse but a uniform declination to all these requests for conference and interchange of thought between the specialists of the two hemispheres. I believe that some action should be taken at once in this matter. National pride alone should dictate a different policy than that heretofore pursued. If there be fear in any quarter relative to an abuse of such a provision of law, a commission might easily be established, to be composed of different officials, to pass upon the necessity or desirability for an investigation in the directions to which I have alluded.

DEPARTMENTAL REPORTS.

The reports of the Department consist of annual, monthly, and special volumes upon the various subjects with which it deals. The demand for this agricultural literature is annually increasing, and the record of the folding-room of the past year shows that the number of volumes distributed among the people has been greater than ever before in the Department's history.

The Annual Report of 1885 has been printed during the current year, by order of Congress, 310,000 copies in number, of which 280,000 are held for distribution by Senators and Members of the House of Representatives, and 30,000 copies assigned to this Department. Reports have been printed by the Department as follows:

DIVISION OF STATISTICS—NEW SERIES.

	No. copies printed.
No. 25. Report on the crops of the year and on freight rates of transportation companies. December, 1885. 55 pp., octavo	15,000
No. 26. Report upon the numbers and values of farm animals, on the cotton crop and its distribution, and on freight rates of transportation companies. January and February, 1886. 56 pp., octavo	15,000

	No. copies printed.
No. 27. Report on the distribution and consumption of corn and wheat, on the production of European wheat, and on freight rates of transportation companies. March, 1886. 49 pp., octavo......	15,000
No. 28. Report of the area of winter grain, the condition of farm animals, and on freight rates of transportation companies. April, 1886. 61 pp., octavo........	15,000
No. 29. Report on the condition of winter grain, the progress of cotton planting, and on freight rates of transportation companies. May, 1886. 48 pp., octavo........	15,000
No. 30. Report of the acreage of spring wheat and cotton, the condition of winter grain, and the world's supply of wheat, with freight rates of transportation companies. June, 1886. 45 pp., octavo.	15,000
No. 31. Report on the area of corn, potatoes, and tobacco, and condition of growing crops, and on freight rates of transportation companies. July, 1886. 45 pp., octavo........	15,000
No. 32. Report on the condition of growing crops and on freight rates of transportation companies. August, 1886. 52 pp., octavo.....	15,000
No. 33. Report on the condition of crops in America and Europe and on freight rates of transportation companies. September, 1886. 56 pp., octavo........	15,000
No. 34. Report on condition of crops, yield of grain per acre, and freight rates of transportation companies. October, 1886. 39 pp., octavo........	15,000
No. 35. Report on yield of crops per acre and on freight rates of transportation companies. November, 1886. 72 pp., octavo.........	15,000

ENTOMOLOGICAL DIVISION.

Bulletin 9. The Mulberry Silk Worm, being a manual of instructions in silk culture. By C. V. Riley, M. A., Ph. D., Entomologist. Sixth revised edition, with illustrations. 65 pp., octavo...........	3,000
Bulletin 11. Reports of experiments with various insecticide substances, chiefly upon insects affecting garden crops. Made under the direction of the Entomologist. 34 pp., octavo...............	3,500
Bulletin 12. Miscellaneous notes on the work of the division for the season of 1885. Illustrated. 47 pp., octavo........	1,500
Insects affecting the orange. Report on the insects affecting the culture of the orange and other plants of the citrus family, with practical suggestions for the control or extermination, made under the direction of the Entomologist. By H. G. Hubbard. With plates and wood-cuts. 227 pp., octavo........	1,200

CHEMICAL DIVISION.

Bulletin 7. Methods of analysis of commercial fertilizers. Proceedings of the Association of Official Chemists. September 1 and 2, 1885. By H. W. Wiley, Chemist. 49 pp., octavo........	1,000
Bulletin 8. Methods and machinery for the application of diffusion to the extraction of sugar from sugar-cane and sorghum, and for the use of lime and carbonic and sulphurous acids in purifying the diffusion juices. By H. W. Wiley, Chemist. 85 pp., octavo..	5,000
Bulletin 9. Third report on the chemical composition and physical properties of American cereals, wheat, oats, barley, and rye. By Clifford Richardson, Assistant Chemist. 82 pp., octavo......	2,000

	No. copies printed.
Bulletin 10. Principles and methods of soil analysis. By Edgar Richards, Assistant Chemist. 66 pp., octavo	2,000
Bulletin 11. Report of experiments in the manufacture of sugar at Magnolia Station, Lawrence, Louisiana, season of 1885-'86. Second report. By Guilford L. Spencer, Assistant Chemist. 26 pp., octavo	2,000
Bulletin 12. Methods of analysis of commercial fertilizers. Proceedings of the third annual convention of the Association of Official Agricultural Chemists, August 26 and 27, 1886. By H. W. Wiley, Chemist. 59 pp., octavo	2,500

BOTANICAL DIVISION.

Bulletin 1. Report of an investigation of the grasses of the arid districts of Kansas, Nebraska, and Colorado. By Dr. George Vasey, Botanist. Prepared under the direction of the Commissioner of Agriculture. 46 pp., octavo	5,000

MISCELLANEOUS REPORTS.

Special Report 10. A descriptive catalogue of manufactures from native woods, as shown in the exhibit of the United States Department of Agriculture at the World's Industrial and Cotton Exposition at New Orleans, Louisiana. By Charles Richards Dodge. 84 pp., octavo	10,000
Report on the condition of dairying in the principal dairy States for the season of 1885. By Allen Dodge, Dairy Division. 35 pp., octavo	3,500

In conclusion, it gives me pleasure to state that the satisfactory record, now completed, of another year in the history of this institution is due, in a great measure, to the cordial co-operation and hearty sympathy of those having charge of their respective divisions; and also to the intelligent, zealous, and faithful performance of the duties imposed upon the clerks and employés. The Department, under these influences, has made one more step in advance and toward whatever future the legislative branch may lay out for it.

Very respectfully, your obedient servant,

NORMAN J. COLMAN,

Commissioner of Agriculture.

REPORT OF CHIEF OF SEED DIVISION.

SIR: In accordance with your request I herewith submit my second annual report. So far as I have been able I have endeavored to aid you in complying with the spirit and letter of section 527 of the act of Congress creating the Department of Agriculture, which provides that "the purchase and distribution of seeds shall be confined to such as are rare and uncommon to the country, or *such as can be made more profitable by frequent changes from one part of the country to another*, * * * and to promote the general interest of horticulture and agriculture throughout the United States."

By reference to the tabulated statement with which the present report is concluded, it will be seen that, aside from the usual distribution to members of Congress and miscellaneous applicants, a regular system of distribution has been begun to experiment stations, agricultural colleges, agricultural societies, and to graduates of agricultural colleges who are now engaged in farming. The reports usually received from those to whom the seeds have been sent being as a rule not only exceedingly limited in number but somewhat imperfect, so far as they relate to the adaptation of new and valuable seeds to the various localities to which they were sent, it was deemed advisable to issue circular letters of inquiry with the view of subsequently tabulating the replies for publication in the annual reports. The responses received at this comparatively early date indicate that the plan will be successful, and the amount of practical information for use in the annual reports of this division will eventually be greatly increased.

In addition to the reports from experiment stations, agricultural colleges, and agricultural associations on seeds sent out by this division, I also present a condensed report on grasses, grains, and vegetables from States and Territories. While in some instances these reports are not as full as could be desired, they indicate to some extent the result to be attained when the system is further perfected. Some of the reports received were valueless on account of the failure to give names of varieties.

An earnest and measurably successful effort has been made to distribute seeds in the special localities to which they are presumably the best adapted. The directors of many of the agricultural experiment stations have expressed themselves as being well pleased with the hearty co-operation now existing between experiment stations and this division of the departmental service. Good results are likely to accrue to the agricultural interests of the nation, particularly when the present system of reports of experiments shall be still further perfected. The special study of the needs of the various sections to which the seeds are sent has proved to be a very essential part of the work to be performed, since it is a well-known fact that although some seeds do well in one locality and under certain climatic conditions, they prove to be utterly worthless in others.

With the view of obviating one of the just causes for complaint as to the quality and vitality of the seeds distributed by the Department, a system for the testing and examination of all seeds before payment is made for them has been adopted. A test of the germinating qualities of the seed is made in what is known as the "Department seed-tester," and under the most favorable circumstances in the propagating-houses in the Department grounds. By means of this double test, errors are avoided, and no seedsman or grower of seeds has yet questioned the conclusions arrived at by those having this matter in charge. The testing apparatus consists of a heavy block-tin pan, 17 inches in length, 12 in width, and 2¾ in depth. This is painted inside and out. Inside of the top of the pan are grooves, in which a thick pane of glass is placed for a cover when needed. Along the inside of the sides there is a ledge or projection half an inch in width, 2 inches from the bottom, upon which the ends of the brass rods, 11¾ inches in length, rest. Fifty of these are sufficient. The rods are required to support the V-shaped pockets, which extend across the pan, and are made as follows: Take two strips of muslin, each 10¼ by 2½ inches. On one edge of each make a hem $\frac{7}{16}$ of an inch in width. Stitch the two pieces together 1⅛ inches from the unhemmed edge, and pass the rods through the hems. Cover the bottom of the pan with tepid water to the depth of half an inch, or enough so that the lower edge of the muslin is immersed, and the cloth is kept moist by capillary attraction. The seeds to be tested are accurately counted and placed within the muslin trough and moistened, and the exact time noted. The pan is then covered and placed in a position affording the requisite warmth. From time to time the process of germination is observed, and when a sufficient period has elapsed the germinated seeds are counted and the relative number of sound and unsound ones determined. The average germination of all seeds accepted was 93 per cent. When the percentage in those varieties which are somewhat difficult to germinate approximates 75 to 85 per cent. the seed is regarded as being of sufficient value to warrant its purchase and distribution. In the tests of flower seeds the percentage usually ranges from 75 to 80 per cent. During the past year a considerable quantity of seed has been returned to the growers because of its lack of freshness and vitality. Without the proper appliances for testing the seed several thousand dollars' worth of seed might have been put up and distributed by the Department, which would have been justly blamed therefor.

THE SEED DIVISION LIBRARY.

The library now includes a complete list of the Reports of the Department of Agriculture, and an index to them, up to the present time. Also, the latest reports of the secretaries of the various State boards of agriculture, as well as those of the experiment stations in the States and Territories.

IMPROVED METHODS OF DISTRIBUTION.

The efficiency of the work in the Seed Division has been materially increased by clearly defining the duties of my assistants and exacting strict attention to the details of the work to be accomplished. As a result, the large and varied assortment of seeds which had been put up and labeled and made ready for the beginning of the special and general distribution early in December last, and the various seeds

now being put up, are more equally distributed, and in much greater variety, than has heretofore been attainable. This is important, as, in justice to the members of Congress, statistical correspondents, and others, the distribution should include the largest number of varieties possible. By the present method not less than thirty additional varieties are now systematically sent into each Congressional district, which is a matter of no little importance, as the greater the number of varieties the greater is the possibility of widely disseminating such seeds as are "rare and uncommon," or, to say the least, of determining their adaptedness to the locality. It is a well-known fact that if some kinds of seed are not changed, the crop will soon run out. This fact is true of grains, but applies to a larger extent to garden vegetables. The thousands of letters received during each year and referred to the Seed Division are ample evidence that such is the fact. The testimony as to the value of the seeds distributed during the past fiscal year has been both general and emphatic. For instance, Maj. H. E. Alvord, director of the Houghton Farm experiment station, in a report to the Department dated May 4, 1886, says:

> The seeds received this season, as a whole, *for the first time* since my experience with the Department, answered the definition of new and useful.

REPORTS OF EXPERIMENT STATIONS, AGRICULTURAL COLLEGES, AND ASSOCIATIONS.

ALFALFA.

Colorado Agricultural College: Reports alfalfa an entire success. If the land is kept well irrigated two crops can be taken the first season, yielding three and four tons to the acre. The second season three cuttings can be made, yielding seven tons per acre. This year the second crop grew 42 inches in thirty days, so thick and heavy one could not walk through it. When once well rooted it appears to be an impossibility to kill it. Plowing it under, like clover, only makes it grow better. After having been plowed under and the land sowed to oats, 3 tons of alfalfa per acre were cut after 42 bushels of oats per acre had been harvested. Wheat, corn, and potatoes are raised with excellent success after plowing it under, and without interfering with the stand of alfalfa the next year. Of the clovers, alfalfa will always head the list in this region. In some respects it is unequaled, as it has unrivaled vigor of stem and root, the latter qualification enabling it to survive our seasons of scantiest water supply, which the grasses will not do as a general rule, an irrigation in the fall being a desirability and often a necessity to insure their wintering safely, and this in some seasons might prove to be impossible to accomplish, owing to lack of water in our streams, especially if a large area had to be irrigated.

Indiana Experiment Station: Alfalfa does well, but must be sown in drills to secure a stand. In the western part of the State it is not considered a profitable crop.

Louisiana, Saint Helena Parish: Alfalfa did well on dry, good land.

Michigan Agricultural College: Alfalfa does well on dry upland, but does not get a good stand until the second year. Clover is considered better in a rotation of crops.

Missouri Agricultural College: The soil in this section is not adapted to alfalfa. In the southern part of the State it is a success.

Nebraska Industrial College: The seed was sown broadcast, and failed to maintain itself against weeds.

New York Experiment Station: Alfalfa is a success. Four crops per year can be cut. At Houghton Farm, sown broadcast, it failed to start soon enough to keep ahead of the weeds. Sown in drills June, 1885, and thoroughly cultivated through the season, it was in bloom May 15, 1886, and gave a fair crop. About 25 per cent. of the area winter-killed; the remainder was 1½ feet high, with rather wiry stems, at time of cutting.

Pennsylvania State College: Alfalfa set well the first year, and grew sufficiently to yield several fair cuttings. Height when in bloom, 21 inches. Experiments to be continued.

South Carolina Experiment Station: Reports alfalfa as thoroughly adapted to the soil and climate, and considered a most valuable forage plant.

Texas Agricultural College: Alfalfa does well only on rich land, and is a good crop. In Gonzales County it does well, and is the most valuable feed grown there; also in Travis County.

BARLEY (*Melon*).

Georgia, Clay County: This barley makes good winter pasturage.

Indiana Experiment Station: Melon barley is not considered superior to native barley.

Missouri Experiment Station: This variety did well. Gave a nice bright barley; long heads and plump grain.

Nebraska Agricultural College: It failed to maintain itself against weeds.

New York Experiment Station: Reports the Melon barley much later than the common barley. Not considered valuable. Houghton Farm reports a fair crop of plump bright kernels.

Pennsylvania State College: This variety of barley grew well early in the season. Yield was about the average of common barley. Height, 36 inches; length of head, 5 inches. It suffered some from smut.

BARLEY (*Imperial.*)

New York, Monroe County: Imperial barley yielded well; a fine heavy berry.

CLOVER (*Alsike*).

Connecticut Experiment Station: Alsike is considered a valuable crop.

Colorado Agricultural College: Alsike is admirably adapted to our low alkaline lands, where alfalfa would not grow.

Indiana Experiment Station: Alsike valuable chiefly as a honey plant.

Michigan Agricultural College: Alsike falls down too easily to be popular for hay. It is a good honey plant.

Nebraska Agricultural College: It was sown broadcast, and failed to maintain itself against weeds.

New York Experiment Station: Alsike succeeds well here and is a valuable crop. At Houghton Farm it is successful as a forage plant; one of the finest clovers. It was well in bloom 75 days from sowing.

Pennsylvania State College: Alsike set well, but the yield was much less than that of alfalfa or of common clover. Sown on calcareous clay soil. Experiments will be continued.

South Carolina Experiment Station: Plants succumbed to the sun.

CLOVER (*Melilotus alba*).

Indiana Experiment Station: This clover is valuable if cut and fed green.

Iowa Experiment Station: The seed was sown broadcast in well-prepared black loam. Produced one mowing this dry season. Plants appeared healthy all through a protracted drought. Hogs ate the freshly cut clover with avidity.

Louisiana, Catahoula Parish: Reports this clover as growing well and a good honey plant.

Massachusetts, Bussey Institution: This plant grows well even on poor land. A good honey plant.

Michigan Agricultural College: Melilotus alba thrives wherever sown. A good honey plant.

Missouri Agricultural College: It did nicely, giving strong, healthy plants, whose roots found their way into our stiff subsoil.

Nebraska Agricultural College: It failed to vegetate.

New York Experiment Station: A very good bee food, but cattle have a decided distaste for it.

Pennsylvania State College: It grew well in height, but spread only moderately well. Will experiment further.

South Carolina Experiment Station: This clover is an admirable crop, like the alfalfa. Thrives and flourishes in wet and dry weather.

JAPAN CLOVER (*Lespedeza striata*).

Louisiana, Saint Helena Parish: This clover does well.

CORN.

Connecticut Agricultural College: Reports the Early Concord a valuable variety.

Colorado, Jefferson County: Reports the Egyptian Prolific not as good a variety for that section as the White Australian.

Louisiana, Tangipahoa Parish: Egyptian Prolific does well here.

Texas, Gonzales County: Egyptian Prolific grows well and yields abundantly.

Pennsylvania State College: The Little Willis was very late in its development and failed to come near maturity.

Virginia, Spottsylvania County: White Giant Normandy is a splendid variety; large, deep grain, flinty, and very prolific.

COTTON.

Arkansas, Arkansas County: Jower's Improved did not do well. Shine's Early Prolific is a good cotton; bolls well and good staple.

Georgia, Clay County: Jower's Improved is one of the best.

Tennessee, Shelby County: Jones's Prolific, and Zelmar, cluster varieties, good, but not equal to the Peterkin in yield.

Taxas, Gonzales County: Bagley's Prolific did well.

GRASSES.

Colorado Agricultural College: Of the native grasses sent here for trial I have no hesitation in saying that with but few exceptions they are worthless for purposes of cultivation in this region. The kinds I would except are *Phleum alpinum* (native timothy), *Agropyrum-glaucum* (blue stem), *Elymus condensatus* (rye-grass), *Deyeuxia canadensis* (mountain blue-joint). The best of these is blue-stem, our best native upland hay.

The species worthy of trial that occur in this region, in addition to those just mentioned, are *Elymus canadensis,* a rye-grass; Turkey-foot (*Andropogon provincialis*), and *A. scoparius, Panicum virgatum, Chrysopogon nutans* (Indian grass, wood-grass) and perhaps *Muhlenbergia glomerata.* What is especially desired for this region is a good pasture grass. If alfalfa did not bloat cattle and horses we might look no further. Of the species not native to this region, we know of nothing that comes so near meeting this want as orchard-grass. The best tame grasses for this region are tall meadow, oat, orchard, and timothy, with tall fescue worthy of further trial.

Indiana Experiment Station: Festuca is valuable both for hay and pasture.

Louisiana, Saint Helena Parish: Rescue and Bermuda do well.

Nebraska Agricultural College: Grasses from Texas all failed here except *Panicum Texanum,* which made a fair growth, but being an annual, cannot compete with perennial grasses.

Tennessee Experiment Station, Knoxville: Reports *Ericoma cuspidata* a good grass. *Poa Nevadensis,* like blue-grass, a good grass. Mixed seed from Colorado, fine in texture, good lawn grass. In Shelby County, Kentucky blue-grass will grow, but is not a success, except in a few yards.

Virginia, Spottsylvania County: The Department lawn-grass seed did splendidly, and makes a fine appearance, notwithstanding the dry weather.

MILLET (*Golden*).

Louisiana, Tangipahoa Parish: Reports golden millet as growing finely and a fine forage crop. In Saint Helena Parish it also does well.

Louisiana, East Baton Rouge: Australian millet is a success.

Tennessee, Shelby County: Golden millet does well.

MUSKMELON (*Spanish*).

Indiana Experiment Station: This is an excellent melon as grown here.

New York Experiment Station: The plants made a vigorous growth, but no fruit ripened.

Tennessee Agricultural College: Did not fruit.

OATS.

Indiana Experiment Station: Reports the White Victoria as only medium.

Kentucky, Christian County: White Victoria and Harris both yield well. Valuable.

Louisiana, Tangipahoa Parish: The Early Burt is the earliest and best and is rust proof.

Mississippi, La Fayette County: Burpee's Welcome does not succeed here. The Early Burt is a success.

Missouri Agricultural College: White Victoria gave a tall, branched, very white, heavy oat, of medium size; promises well.

Nebraska Agricultural College: White Victoria sown broadcast failed to maintain itself against weeds.

New York Experimental Station: White Victoria medium good. Very closely allied to the Welcome, differing only in time of maturity.

Houghton Farm: White Victoria gave a fine crop of plump, heavy oats in well-branched heads. Straw leafy and fairly tall.

Pennsylvania State College: White Victoria a good variety; plump and heavy grain. A more valuable oat for this locality than the Harris, notwithstanding the earlier maturity of the latter.

Tennessee Experiment Station, Knoxville: White Victoria did not succeed.

Virginia, Spottsylvania County: Russian oats made a fine yield; evidently could be profitably grown here.

POTATO SEED (*Pringle's Hybridized*).

Colorado Agricultural College: From this seed over 2,000 plants were raised and set out in the open ground; 55 of the most promising were saved for trial another season. Nearly all the plants bore some tubers, but only such as bore tubers of fair size, close in the hill, and with a moderate amount of haulm, were thought worthy of trial again. The weights of such varieties as were weighed varied from 3 ounces, the lowest, to 4 pounds 11 ounces, the largest yield from one plant.

Connecticut Experiment Station: The potato seed produced small, well-shaped tubers. At the Storrs School they produced remarkably, some of the tubers being as large as small hens' eggs. They are preserved for planting next year.

Massachusetts, Bussey Institution: Reports potato seed planted at Pembroke. The experiment was a great success in spite of drought. Some of the tubers grew to be as large as a man's fist.

Michigan Agricultural College: The potato seed gave a bountiful harvest of tubers. We have a half bushel of these, which we shall test further.

New York Experiment Station: "Pringle's Hybridized" potato seed grew well. Will test further.

Houghton Farm: Potato seed gave a fair crop of small tubers of the most diversified characteristics, which promise some very interesting results from future crops.

Tennessee Experiment Station: About two quarts of small potatoes; shall experiment further.

PYRETHRUM ROSEUM.

Connecticut Experiment Station: Seed of this plant was sown in 1884, bloomed in 1885, and then died.

Michigan Agricultural College: The seasons are too cool and short for the profitable growth of this plant.

New York Experiment Station: The plants grew well, blossomed, and some of them matured their seed.

Pennsylvania State College: Did not bloom.

RUSSIAN FORAGE PLANTS.

Colorado Agricultural College: Ieradella forage plant imported from Russia is too slow of growth in this region to be of any agricultural value.

Spergula maxima: This plant, like the last, lacks the vigor to be of value here.

Puff Bean: This forage plant from Russia is of extremely vigorous habit, even on the thinnest soils, and is perhaps worthy of further trial. It very closely resembles the English broad bean (*Fata vulgaris*).

Jaegar bean: This bean resembles the last very closely and is of equally vigorous habit. Hogs ate both plants with avidity.

Yellow lupin: Sheep-fodder from Russia. A plant of medium vigor, and, like all the lupins, impatient of much irrigation. Would have but little value in competition with more vigorous species.

Vicia villosa: Sheep-fodder from Russia. Height about 3 feet. A vigorous grower; foliage abundant; flowers purple. Worthy of further trial.

Dakota Territory, Grant County: The *Vicia villosa* is well suited to this climate and soil.

Indiana Experiment Station: Reports the *Vicia villosa* as the only variety that proved of value. The drought affected the others.

Iowa Experiment Station: Reports as follows: *Vicia villosa*, two plats, each 4 by 12 feet, were sown May 5. A thin stand secured. The growth was slow during May and June. July and August being exceedingly dry but little growth was made, though the plants remained healthy, and when the fall rains came on they continued their growth somewhat. The plants began flowering May 26, and continued in flower as late as October 16. Stood in the plats 20 inches high, but the scandent vines were much longer. Probably not over a ton and a half of dry fodder was produced per acre.

Ieradella: This variety, sown May 5, on May 22 was just starting; on July 3 was 5 inches high and blossoming; on August 7 it was fourteen inches high and was mown. The second growth stood 4 inches high August 21 and was beginning to blossom. Blossoming continued until October 2, when the plants stood 8 inches high. Plants resist considerable frost.

Spergula maxima: Sown May 5, came up May 13, and grew vigorously; June 12 it stood 14 inches high and was in bloom. It was sown so thick that the plants were much crowded.

Iowa, Kossuth County: None promise well except the Blue lupins, which survived the drought and made a tremendous growth after the fall rains.

Michigan Agricultural College: All made a fair growth for the season, which was very dry, and seem promising enough to warrant further trial.

Missouri Agricultural College: The Puff and Jaegar beans were not a success here. *Vicia villosa* perfectly suits soil here, and is a very promising plant.

New York Experiment Station: None of these seem adapted to the soil.

Houghton Farm reports as follows:

Ieradella: Growth small; kept fresh and green, despite the drought, until after several hard frosts; eaten eagerly by cows; might prove a good grazing plant.

Spergula maxima: Growth not large enough for profit.

Vicia villosa: Made luxuriant growth, bloomed and seeded; should be a good soiling crop when sowed with rye. Eaten eagerly by cows.

Jaegar bean: Capable of producing a heavy crop per acre.

Puff bean nearly the same.

Blue and Yellow lupins did not do well. On account of heavy rains in May the ground was very wet, and these seeds were not sown until June 8; hence the growing season previous to the drought, which set in early in August, was short. The whole lot of plants completed their growth under exceptional conditions, and some of them were doubtless dwarfed by the severe drought, which continued until after the crop was gathered.

New Jersey, Salem County: Vicia villosa and Ieradella did not succeed well. *Spergula maxima* grew very well and would yield a large amount of fodder. It does not stand up well, which is a disadvantage. The plat was mown pretty close June 19, and all but a little around the edges was killed out by the drought. A few plants in the borders show that it resists quite severe frosts.

Puff bean was planted in drills about 1 foot apart May 5. Began to blossom June 9, and continued until July 3. Plants stood 33 inches high. In July and August the plants suffered considerably from drought. A rather small crop of beans was produced. Would doubtless do better in this climate in a more favorable season. Some seedlings that have come up since the fall rains show that this bean resists frost almost as well as red clover.

Jaegar bean: Same report as puff bean, except that these seemed less affected by the dry weather.

Blue lupins: Two small plats were sown May 5, in drills about one foot apart, and cultivated with the hoe. Blossomed about July 3. August 7 the plants stood 35 inches high and appeared promising. They were much reduced in size by the dry weather.

Yellow lupins: Report the same as in Blue lupins, except that they measured but 19 inches August 7, when in blossom.

Pennsylvania State College: None of these did well except *Vicia villosa:* that grew luxuriantly, and was still blossoming after severe frost. Cattle ate it with avidity when in the fresh state.

Texas, Limestone County: The sheep-fodder and hog-bean are a valuable addition to our forage.

Virginia, Hampton School: Made a fine growth, but not thought superior to the black or cow pea for this locality.

Virginia, Spottsylvania County: Sheep-forage made a fine yield, and is valuable.

SORGHUM (*White African*).

Indiana Experiment Station: Reports this variety only medium.

Missouri Experiment Station: It did admirably.

SUGAR BEET.

Connecticut Experiment Station: Mangel-wurzel is preferred here to the sugar beet for stock.

Georgia, Clay County: It succeeds well, and is good feed.

Kansas, Ellis County: The sugar beet succeeds well. Root crops, such as beets, rutabagas, mangel-wurzel, &c., are valuable on account of not being liable to injury from insects, which frequently entirely destroy other field crops.

Louisiana Experiment Station: Sugar beets grew very large. The largest sugar content was July 13, 3 per cent.

Louisiana, Catahoula Parish: The sugar beet was a success.

Massachusetts, Bussey Institution: This beet did well at Pembroke.

Mississippi, La Fayette County: It did well, yielding bountifully.

TEOSINTE.

Louisiana, East Baton Rouge Parish: Reports teosinte planted too late to mature seed. November 8, height 10 feet. Put forth from 20 to 40 stalks from the first stalk. If it can be planted early enough to mature seed will be one of the finest forage plants grown here.

Louisiana, Tangipahoa Parish: It made a wonderful growth; stock very fond of it.

Lousiana, Saint Helena Parish: Teosinte bids fair to make one of our best forage plants, and will ripen seed if planted by March 1. Gives three to four cuttings.

Mississippi, La Fayette County: It is the most prolific forage plant I ever saw.

Texas, Limestone County: If planted very early, the teosinte is a most prolific and valuable forage plant here.

Tennessee, Shelby County: It did not succeed well; perhaps was planted too late; still have hope of it.

TOBACCO.

Colorado Agricultural College: Nine varieties of tobacco from the Department of Agriculture were grown the past season. The seed was sown in a mild hot-bed April 27, and transplanted to open ground June 1, not a plant failing to grow. Our notes on these varieties are as follows:

Vuelta Abajo: This variety is a vigorous grower. Leaf smooth; shape, ovate-lanceolate; greatest length of leaf, 35 inches; width, 20 inches. It is a late variety, and did not ripen well.

Figi Orinoco: Leaf coarse; shape, lanceolate; greatest length of leaf, 34 inches; width, 15 inches. This variety ripened and colored a deep yellow.

Caboni: A dark green, rough leaf when growing, which cured into a reddish-brown; greatest length of leaf, 33 inches; width, 13 inches. Quality good.

Big Orinoco: Has a rough, dark leaf when growing, which did not ripen thoroughly; greatest length of leaf, 38 inches; width, 20 inches.

General Grant: Leaf rough and crimpled; shape, ovate-lanceolate; greatest length of leaf, 38½ inches; width, 17 inches. Much like Golden Leaf in flavor, color, and desirability.

Hungarian: This variety cured a light yellow leaf of mild flavor; longest leaf, 34 inches; width, 15 inches.

The experiment with this plant is not yet complete, as the leaf needs more age before one can speak definitely as to the desirability of these varieties for this region and as to the quality of the tobacco grown.

Competent judges, however, at this stage of the experiment, speak favorably of the burning qualities and flavor of the kinds grown, so that another season's trial, and with early maturing varieties, would settle the question of the profitable culture of the tobacco plant in this State.

Parts of Colorado would seem to possess some positive advantages over the Eastern States in the culture of tobacco, and these are: first, a long dry season, insuring the ripening of the latest kinds; second, the presence of irrigation, enabling us to set out plants at the earliest possible moment and insuring a perfect stand; and, third, the absence of fall rains would assure to us the perfect curing of the leaf.

Tennessee Experiment Station, Knoxville: Big Orinoco very good. White Burley very good. Gooch's Broad-leaf fine; leaves 18 inches long and 9 wide.

Virginia, Hampton Normal School: Connecticut-seed Leaf made a fine growth; rather coarse and heavy in quality.

TREE (*Tartarian maple*).

Colorado, Jefferson County: Made but little growth; seems tender.

Indiana Experiment Station: Did very poorly.

Michigan Agricultural College: It makes a desirable ornamental shrub here.

Missouri Agricultural College: It is not entirely hardy here.

Texas Agricultural College: The plants summer-killed.

TURNIPS.

Connecticut Experiment Station: All the varieties of field turnips did well and proved distinct and valuable.

Indiana Experiment Station: Purple Top Strap-leaf is the best. Milan Strap-leaf next. The Garden Rose did not do well.

Louisiana, Tangipahoa Parish: All the varieties of turnip did well.

East Baton Rouge Parish: Reports all the turnips as doing well—better than any other raised there.

La Fourche Parish: Reports the Purple Top as giving excellent results, although the weather was exceedingly dry.

Massachusetts, Bussey Institution: The turnips all did well at Pembroke.

New York, Monroe County: The turnips were excellent. Did well in the hands of five or six parties.

Texas, Limestone County: The turnips are a success, especially the Purple Top.

Tennessee Experiment Station: Great Southern Prize good for greens. Purple Strap-leaf very productive and keeps well. White Norfolk Extra very productive. Red Top Globe best of all for quality and productiveness. All the turnip seed was sown August 15 and turnips gathered November 4.

Tennessee, Shelby County: Garden Rose and Milan Strap-leaf extra good.

WHEAT.

Michigan Agricultural College: Reports that the imported varieties—Genoese, White Crimean, Egyptian, and Indian—grew vigorously in the fall, but were not sufficiently hardy to withstand the winter. The Extra-Early Oakley also proved too tender for this latitude. The Diehl Mediterranean is a bearded variety, having heads about 3 inches in length. The straw is long and strong, being about 4 feet in length over the whole plat; no smut or rust; 3 to 6 stalks to the stool; thick on the ground; ready for harvesting July 1, the berry being plump and hard. McGhee's White showed some rust on the

leaves, and a good many stalks were cut down by the "fly;" no smut, but ripened unevenly.

Missouri Experiment Station: Reports the Crimean a coarse wheat, mostly winter-killed. The plants saved made a grand head to look upon—long, full, and evidently very prolific, but a large, coarse wheat. The Indian and Egyptian wheat all winter-killed. The Diehl Mediterranean stood the winter well and gave a good berry, but ripened late. The Genoese was a failure, giving a very poor return. The McGhee White gave a moderate yield of a most beautiful wheat, of light color, with a glazed or pearly luster. Ripened June 16.

Nebraska, Pawnee County: The Sheriff wheat winter-killed badly.

New York Experiment Station: Diehl Mediterranean is well adapted to this climate. Martin's Amber is first-class. Genoese, White Crimean, and Egyptian are failures as winter varieties and of no value as spring varieties, the grain not maturing sufficiently. The last is not the true Egyptian wheat (*Triticum vulgare,* var. *compositum*). This variety has a simple panicle; the true Egyptian wheat, as usually understood, has a composite head, according to all authorities.

Pennsylvania State College: Reports eight varieties sown side by side. From observation taken October 31, 1885, the White Crimean, Genoese, and Egyptian were doing excellently. The Indian did not come up well. All the imported varieties winter-killed. The exposure was somewhat exceptional, it is true; nevertheless they seem too delicate for our winters here. At the same date (October 31) it was noted that the McGhee and Early Oakley had a good, deep color, and were well advanced. The Diehl Mediterranean had an excellent color, was well stooled, and taller than either of the other American varieties. Martin's Amber was inferior in color, and not very well stooled. The final height attained by all these varieties was about 4½ feet. The straw seemed nearly alike in stiffness. The Diehl Mediterranean was the only one bearded. The yield from one quart of seed was: McGhee, 22 pounds; Extra-Early Oakley, 22 pounds; Diehl Mediterranean, 60 pounds; Martin's Amber, 13 ounces. All suffered considerably from the "fly." We are trying the first three American varieties again.

South Carolina Experiment Station: Reports the Extra-Early Oakley a very early variety; yielded an excellent crop; an admirable variety for this latitude, and much valued. Yielded about 20 bushels per acre. McGhee's White—another excellent variety, a week later than the Oakley, yielded well; a good Southern wheat. The Diehl Mediterranean—an excellent bearded variety, rather late, but made a fine yield. The Four-Rowed Sheriff—too late for this latitude. The Egyptian, Crimean, and Indian varieties were all killed by cold. Martin's Amber was about half killed; yield unsatisfactory. These varieties were all drilled and cultivated; all fertilized alike and closely observed.

Virginia, Hampton School: The Red Mediterranean seems to be the only wheat that is at all sure here.

REPORTS FROM CORRESPONDENTS

ALABAMA.

Grasses and forage plants: Grasses are very little grown in Northern Alabama, but we badly need something that will afford good pasture. Crab-grass grows in abundance, and makes excellent hay. Alfalfa does well, but very little is planted.

Our most popular grasses are clover, orchard, herd's or red-top, Texas blue, and Bermuda. Kaffir corn grows vigorously, producing a mass of foliage of rich deep-green color. It continues its growth till frost, and successfully withstands drought. It produces, besides the mass of foliage, an immense crop of seed, exceeding in yield per acre the Millo maize. It is quite promising as a source of coarse forage, as well as for grain for stock.

Grain: Our most popular grains are corn, wheat, oats, barley, and rye. We usually commence planting corn the 1st of March, which makes large, heavy ears. Corn is planted from March to June; oats, corn, wheat, and rye for seed are best for this climate if raised south of Tennessee. If raised north of the Ohio River, they will not succeed well. The Fultz, Early Red May, and Mediterranean wheats are the best varieties in Northern Alabama. Very little wheat is sown, as it is almost invariably injured by rust. We need a rust-proof variety adapted to our climate. Red rust-proof oats, one of our best varieties, are sown from November to March. Barley grows finely on rich land, and small grains yield more abundantly when sown in October.

ALASKA.

Grain: The land laws are such that the privilege of acquiring a title to land is expressly denied, hence there is no encouragement to agriculture on any extended scale; otherwise it is believed cattle-raising, at least, would be largely followed. The shores are never covered for any length of time by snow in the winter, so cattle have been known to live through the winter without other food than what they found themselves. The climate is probably too rainy for grain culture in this part of Alaska. Barley and oats grow luxuriantly, but are difficult to ripen and cure. Timothy and clover grow luxuriantly. Wheat has not been fairly tested.

Vegetables: The following are all the vegetables that can be grown here with profit: Potatoes, planted in April; cabbage, cauliflower, turnips, peas, lettuce, beets, carrots, and salsify, planted in May. The above have been raised with success, and in quantities to suit the demand. Tomatoes, cucumbers, corn, melons, pumpkins, &c., will not grow. In Klawock there is no farming carried on; the country is heavily wooded, although there are several clear tracts of land which could with comparatively small outlay of money be turned into good farms. However, the cost and opportunities of transportation between the different points in Southeast Alaska would make it almost impossible at present to find a paying market for products raised.

ARKANSAS.

Grasses and forage plants: Millet is the chief forage plant. It is planted in June. Some red clover is grown. The different kinds of grasses are not grown extensively, but experiments are teaching us that this is a fine grass country. Crab-grass makes an excellent pasture and is used for hay. The usual time for sowing clover, blue, timothy, and herd's grass is in the month of February. There is a desire to try other varieties than those we now have. Bermuda grass is our best grass for summer grazing, and on rich land makes fine hay. Johnson grass has proved a great success to all who have tried it. Alfalfa and red clover grow finely here on our best land. It is a difficult matter to get the people aroused to the vast importance of giving more time and attention to different grasses and forage plants.

Grain: We commence plowing in February. Amber wheat and similar varieties do the best in our locality. Our climate requires a wheat that is early and will stand the rust. The Walker wheat is a popular variety. Wheat and rye are sown in October. Rye is a profitable crop if sown earlier. We are growing more grain and less cotton. Late corn has proved to be best for our climate, making the largest yield per acre. Corn is usually planted in April. White winter oats sown in the fall make a good yield, and are free from rust. Barley and rice are raised to a limited extent.

Vegetables: All vegetables grow to perfection in this climate; we grow almost every known variety with little labor. Gardening is commenced in February and March; early and late Flat Dutch cabbage and some drumhead for winter use. Irish potatoes must be of an early kind, on account of our hot, dry summers; planted in March. Turnips, purple-top and Flat Dutch, for early use, do well, but for a main crop must have a hardier kind, like the seven top, to stand the winter. Peas, beans, carrots, and parsnips are planted in April.

CALIFORNIA.

Grain: Winter plowing and seeding commences in Northern California as soon as the soil is wet enough to plow. The principal grains are barley, oats (mammoth),

Egyptian and eight-rowed corn. Only the early varieties of corn will mature in Northern California. In the southern part of the State it makes a large and valuable crop. Flax is grown for its seed; sometimes one and a quarter tons are produced per acre. Barley known as the Coast Range variety is a profitable grain.

Grasses and forage plants: Very few grasses are raised in Northern California. Alfalfa is grown along the river bottoms or in places that can be irrigated; it is used in Eastern California for hay; it yields two cuttings a season on dry land.

Timothy and red-top do well on wet land, and yield from eight to ten tons of hay per acre. In Central California white Chili wheat and white wild oats are sown for forage.

Vegetables: Vegetables grow to perfection, and gardeners plant nearly every month in the year in the southern section. The Lima bean is a valuable crop in the south.

CONNECTICUT.

Grass and forage plants: Clover, timothy, red top, orchard grass, blue grass, tall fescue, red and white clover, and alsike are the most profitable.

Grain: Wheat, yellow Dent corn, barley, oats, and buckwheat are the principal grains.

Spring plowing usually begins April 1 and grain sowing about April 10. Corn ripens in from 90 to 100 days from planting.

Vegetables: The melon trade is growing, particularly the small green-fleshed varieties of musk-melon. Hackensack stands at the head. We plant the first week in May. The leading vegetable in the southwest is the onion. There are growers who plant twenty to thirty acres annually. The average yield is three hundred to four hundred bushels per acre; the principal market for this product is New York City. Carrots are raised in large quantities, more particularly for stock and horse feeding. Pumpkins, largely grown for cattle and hog feeding; time for planting about June 10.

DAKOTA.

Grasses and forage plants: Only wild grasses grown at present. Clover, alfalfa and the hardier grasses would do well, as the winters, although extremely cold, are not subject to thaw, which causes grasses to winter-kill. The country being new, grasses have not been cultivated. Native grasses are preferable to any others; their fattening qualities are greater than the native or tame grasses of Illinois or Iowa.

Grain: The varieties of spring wheat grown in Southwestern Dakota have a world-wide reputation for producing the best quality of flour. Spring varieties of wheat are harvested 118 days from sowing. The early-sown grain produces a larger yield, and a great effort is made to get seeding done by the 10th of April. In 1886 wheat yielded from 9 to 20 bushels to the acre. Fall plowing is necessary for the best yield for wheat. Scotch Fife is the favorite variety.

Our principal market crop is flax. Welcome oats is a favorite variety. Corn does well planted any time from the last week in April to May 25. Rice-corn is a variety that should be cultivated and improved by the settlers in Dakota. Barley does better sown about the 20th of April. Amber cane does well, but has not been extensively grown for lack of mills.

Vegetables: Nearly all kinds of vegetables are of excellent quality and very prolific. Some of the carrots are 2 feet long. Specimens of Early Rose potatoes weighed 6 pounds. They average 175 bushels per acre. Sugar-beets, turnips, and rutabagas are extensively raised for stock-feeding. The southern section seems peculiarly adapted to root crops of all kinds. Tomatoes and melons rarely mature, on account of frost.

FLORIDA.

Grasses and forage plants: On the Gulf border of Florida the yellow Millo maize and Johnson grass have been reported by good farmers as excelling all other forage plants. Alfalfa is pre-eminent for hay, soiling, and green manuring. It does not need re-seeding. Bermuda grass is unexcelled for pasture, and once established is permanent. However, the principal dependence is the wild native grasses.

Grain: Oats acclimated here are far superior to any variety raised north. They are planted as late as December. For pasturage, sowing begins in October. Rye and barley are sown in October, and yield well, but the weevil cannot be kept from the grain when it is matured. Northern rye will not grow successfully here, as it does not head out.

Vegetables: There are two distinctive kinds of vegetables grown here—winter and spring. The early vegetable business is steadily increasing with the facilities for marketing. All kinds of vegetables grown in the United States can be successfully grown here at some time of the year. Seed can be planted at any time after the heat of the summer, and suffers, as a general thing, no check, as the winter temperature rarely falls below 50 degrees Fahrenheit.

GEORGIA.

Grasses and forage plants: Very little attention is given to grasses in Eastern Georgia. Lucerne is the best-paying clover we have; crab-grass and crow-foot make excellent hay. Would like grasses in Southwest Georgia adapted to our climate. In the western section Bermuda-grass was introduced some years ago; it does not produce seed, but is easily propagated by the roots. Seven tons have been produced to the acre. Our forage consists mostly of oat straw.

Grain: Rye, oats, and corn are our grain crops. Corn is planted in March and cotton in April. Kaffir corn is creating a great deal of excitement in Western Georgia. It has proved to be an excellent forage plant. The seed commands a high price, but will be within the reach of all by another year. Indian corn is largely used as a forage plant in the northern section. Corn should be procured from other localities and renewed every two or three years. Wheat is not as successful here as in higher latitudes. Wheat is sown in the months of October and November. The Burt rust-proof oats are two weeks earlier than other oats, but the heads are not as heavy.

Vegetables: In Central Georgia dwarf peas, though not so fine flavored as some others, are preferred. Among the best varieties of squash are yellow crook-neck and Boston marrow for fall and winter. Early varieties of Irish potatoes are best, as two crops can be grown. The sweet-potato is entitled to more consideration. The Government should import new varieties from South America. The sweet-potato is deteriorating in the South, losing its keeping qualities from continual propagation from cuttings and sprouts. Potatoes planted in February mature in June. A second crop planted August 10 will mature by frost. This crop keeps through the winter and spring. Almost every variety of vegetables and fruit grow well here. The time for sowing varies every year, owing to the difference in the seasons; therefore it is best to plant and sow something every month. Flat Dutch turnips are in demand in the spring; yellow rutabaga and purple-top in the fall. In the western part of Georgia carrots and parsnips are not grown.

LOUISIANA.

Grasses and forage plants: Millo maize, the sorghums, and millets may be grown profitably either for grain or forage crops. Sorghum is planted in April; millet is sown in May or June. Teosinte bids fair to be one of our most valuable forage plants. Rescue grass is good winter pasture. Crab-grass makes our best hay. In Southern Louisiana cow-pea is the principal reliance of the planters for hay.

Grain: In the central part of the State the old reliable gourd-seed variety of corn is the most popular. The flint variety, on account of its hardness, is rarely planted, except for bread. Oats are sown about the 10th of January. In the eastern section red oats and rice are the principal grains. Rye and barley grow well, but are not raised to any extent. Rye makes poor pasturage, and barley is of but little value for the same purpose. Sorghum is extensively raised here for sirup and forage. Wheat rusts, and but very little is sown.

Vegetables: Most of the garden vegetables are planted between February and April. The best peas in Eastern Louisiana are marrowfat; the dwarfs are not fruitful enough to pay for culture. Drumhead and Flat Dutch cabbage, red-top and white-globe turnips are the favorites. The pole bean and the black wax are preferable. Watermelon seed from the Department of Agriculture the first year made a poor show; the melons split open in the sun, but the year following melons were raised from the same seed, many of which weighed over 40 pounds. Asparagus, celery, carrots, and spinach do not come to perfection here. In Southwestern Louisiana spring vegetables are sown from the 1st to the 10th of March; fall vegetables from the 1st to the 10th of August. There is a growing demand for the early varieties of all kinds of vegetables.

MAINE.

Grasses and forage plants: Timothy and red clover were formerly the only grasses sown, but of late years several other varieties have been added with satisfactory re-

sults. Red-top, Kentucky blue-grass, orchard grass, alsike, and white clover are now largely grown. A mixture of oats, wheat, and barley is quite extensively raised for feed. But little rye or buckwheat is raised in the southern part of Maine. In addition to the other grasses given, foul meadow and blue joint are extensively grown on low and swampy land.

Grains: Spring plowing is sometimes begun earlier than May 1. A mixture of oats, wheat, and barley is quite extensively raised for feed. Peas are sometimes added to make it more valuable.

Among small grains oats have much the largest average; barley comes next. Wheat, rye, and buckwheat receive little attention. Large quantities of sweet and Dent corn are grown to feed while in a green state.

Vegetables: Our chief vegetables are cabbage, beets, carrots, tomatoes, and turnips. The date of planting gardens is about the middle of May, and all the varieties are planted about the same time. Potatoes are grown to a greater extent in the southwestern part of Maine than any other vegetable, but immense quantities of cabbage are raised in a few towns in the southern portion.

Pumpkins are grown for stock in all localities. Squashes and tomatoes are grown by nearly every farmer, and large quantities are raised by market gardeners in the southern section.

MASSACHUSETTS.

Grasses and forage plants: Timothy, red-top, and clovers are the most popular grasses. Hungarian and millet are sown as "catch crops" for forage.

Grain: The grains are corn, oats, rye, barley, and wheat.

Vegetables: Sweet corn is planted every ten days from April 10 to June 17. As a general thing vegetables are planted too early. Later planting would produce better results. Among the best varieties of peas are First and Best and McLean's Advancer.

MICHIGAN.

Grasses and forage plants: The northern part of Michigan is second to none for clover and grasses. Mammoth clover is grown to some extent for plowing under. In the southwestern part a field of alfalfa, sown for the first time last spring, stood the summer drought better than red clover. Timothy is considered the best for hay. Medium red clover preferred.

Grain: There is no part of the State better for winter wheat than the northern portion. Spring wheat is found to succeed better than fall wheat in average seasons. In the central part of the State the Clawson is the most popular at present. Martin's Amber and Centennial are growing in favor. Welcome oats are good. The Russian variety is a little late. Barley does well. What we need most is a good and early field corn. The flint varieties succeed best. The Dent varieties are rather late. Corn planting begins about the 10th of May and continues up to the 1st of June. One hundred bushels per acre is considered a good crop, but a hundred and twenty bushels are not uncommon in favorable seasons with good cultivation. The seasons are too short in the northern part of the State to mature all varieties of corn and potatoes. Early Concord sweet corn proved to be the best late sweet corn ever planted in the southeastern part of the State.

Vegetables: All vegetables do well here. Early Flat Dutch cabbage is always sure to head, also the Winningstadt. The Hubbard squash is the best variety for winter. The season in the northern part of the State is short and the growth of vegetables very rapid.

MINNESOTA.

Grasses and forage plants: As yet we depend mostly on native grasses, though some farmers are beginning to seed with timothy and red-top.

Grain: Wheat, oats, barley, rye, and early corn are grown. No winter wheat is raised. Spring wheat is sown as soon as the ground will permit. Fife and bluestem wheats and white Russian oats are the standards. Scotch Fife makes the best flour under the new process. Wheat and oats are almost invariably sown on fall plowing. Spring plowing for corn and wheat is done from the 10th to the 25th of May. Spring rye is raised to some extent.

Vegetables: Potatoes and rutabagas are the main crop. Garden vegetables are grown for home consumption. Marblehead squash and Stowell's evergreen sweet corn are favorites.

MISSISSIPPI.

Grasses and forage plants: Our red-clay lands produce excellent red clover, which is the most popular of the grasses as a fertilizer and forage plant. Bermuda grass is unequaled for grazing. Our planters are just beginning to find out that grass is their best friend. German millet is cultivated to some extent and yields abundantly. In the eastern section we need some new varieties of clover and grasses for forage. Crab-grass will surpass anything in yield and quantity.

Grain: Red rust-proof oats is the only variety that will do well in Central Mississippi. Grain sowing is usually begun in February and March—in the southern part of the State early in February. We want a rust-proof wheat. Wheat growing has proved unprofitable for several years, and very few farmers are engaged in it. Nearly every variety fails to be rust proof, and rust is a deadly foe to wheat in this locality. Cotton, which is our principal crop, is planted in April. Rye is cultivated to some extent, though mostly for early spring pasture.

Vegetables: We are favorably situated for the business of gardening, and most vegetables can be successfully grown with ordinary skill and labor. Some vegetables can be raised all the year round. Gathered 32 different varieties at one time the 1st of May. In the southern section the wax-bean cannot stand the long hot summer, and in the western part of the State turnips, rutabagas, and cabbage are generally failures. Beauty of Hebron potatoes proved excellent. All turnip seed received from the Department of Agriculture was unusually fine, particularly the red-top and white globe.

MONTANA.

Grasses and forage plants: We have had little experience with grasses. We need a deep-rooted grass, capable of enduring drought. Our most desirable grasses are timothy, alfalfa, orchard, and red-top. In the eastern part of the Territory millet is the most desirable.

Grain: All kinds of grains yield well in Central Montana. The best wheat and barley are raised on bench lands. The most popular varieties of wheat are Scotch Fife and white Sousse. Two-row barley is a very satisfactory crop. We should be able to raise an early variety of corn, but as yet but little attention has been given to this grain. White flint promises to be the best variety. All field crops in this country require irrigation to insure a good yield. Too little attention has been given to raising crops that will withstand drought. Early amber cane attains a good growth and makes fine forage for stock, but will not succeed as a sugar-producing plant. Oats are more extensively sown than any other grain. Morrs Ennobled Black, Welcome, and Surprise oats are successfully grown.

Vegetables: Almost all vegetables are raised in abundance, but the earliest varieties must be selected. Best varieties are Early Rose, Beauty of Hebron, Saint Patrick, and Snow Flake potatoes. Silverleaf, Drumhead, and Jersey Wakefield cabbage planted May 15. Silverskin onions, blood turnip beet, long green cucumber planted April 20. Vegetables grow to an immense size and are superior in quality. Our potatoes cannot be excelled.

NEW HAMPSHIRE.

Grasses and forage plants: Clover, timothy, red-top, blue-grass, orchard-grass, and Hungarian are the favorite varieties.

Grain: Oats, barley, wheat, and rye are successfully grown.

Vegetables: Potatoes are a staple product. Other vegetables do well. Winningstadt cabbage, Early Blood, and Egyptian beets, Danvers and Weathersfield red onions, cranberry and white Dutch pole beans, Boston curled lettuce, nutmeg-muskmelon, black Spanish watermelon, sweet mountain pepper, early scarlet radish, Hubbard squash, General Grant tomato, and strap-leaf turnip are the favorite varieties.

NEW MEXICO.

Grasses and forage plants: Grasses, such as alfalfa, are needed here, and amber or orange cane. The seeds of varieties grown here have been used so long that they have become entirely unprofitable for seed, having been planted year after year.

Grain: Seed wheat adapted to this locality is greatly needed in the southern part of New Mexico. Barley and Canada corn, if planted very early and properly cultivated, yields two crops a year.

Vegetables: Nearly all the seed sent from the Department did well, particularly Flat Dutch cabbage. Potatoes do not grow in this country—eastern part—but do well in the mountains. I have raised sugar beets here that weighed 35 pounds. The red turnip beet is best for table use. All classes of vegetables will do well, however, if sufficient water can be had for proper irrigation.

NORTH CAROLINA.

Grasses and forage plants: The native varieties of grasses succeed better than foreign ones. Timothy, red clover, red-top, and orchard are the most desirable. We have natural pasturage of spontaneous growth. No doubt most of the varieties of grass would do well, but our farmers have never resorted to them. In the southeast there is some millet and sorghum planted for forage. Very little forage grass used, except crab-grass. Most of the planters use the cow-pea and corn for fodder.

Grain: The most popular grains in the northern part of this State are corn, wheat, oats, and rye. Oats are sown from February to April; yellow and white are the most desirable, but the rust-proof varieties are preferred to all others. The best oats for fall sowing are the white winter and rust proof; for spring the black, which is sown from February to March. Very little spring wheat is sown. There is not wheat enough raised in some parts of this State to supply the demand. In the northern part of the State spring wheat has not been sown since 1849. The most popular wheats for red land are the Clawson and Golden Prolific. On sandy soil the Fultz and the Mediterranean, both bearded varieties, succeed well. Wheat and rye are sown from October 1 to December 25.

Vegetables: All vegetables known to the temperate zone grow here to great perfection. In the central part of the State cabbage is the most profitable vegetable grown from summer and early fall. Drumhead and Flat Dutch are the favorites. Nearly all kinds of beans are grown. Our best varieties of tomatoes are Livingston's Perfection and Acme. Lettuce, Early Hanson and Salamander. The sugar beet sent us by the Department is considered the best for table use. Sweet potatoes stand first in quantity and value among vegetables. Irish potatoes are raised in large quantities for early market for Northern cities.

OHIO.

Grasses and forage plants: We need a grass that will stand the drought better than timothy. Experiments with orchard grass very satisfactory; also alfalfa from Department of Agriculture. Alsike is just what we need as a clover; it grows 18 inches high and ripens its seed.

RHODE ISLAND.

Grasses and forage plants: The most desirable grasses are timothy, clover, red-top, and orchard. Forage plants are red clover, corn fodder, millet, Hungarian, and some sorghum.

Vegetables: Our season is a long one. We are subject to dry weather from June to September, and farmers are anxious to get their crops in as early as possible to obtain the advantage of spring rains. The variety of garden seed used is great; onions and carrots are the specialties, red onion preferred.

SOUTH CAROLINA.

Grasses and forage plants: The reliance for pasture and hay is on native grasses or rye, which many plant for winter and spring grazing. Herd's grass grows well on low lands, and crab-grass makes a good crop. Bermuda and Texas blue have both been introduced on a small scale. Pea-vines make fine forage. We plant Bermuda, rescue, orchard, clover, lucerne, and millet in the fall.

Grain: Wheat is sown from October 1 to December 25. Our best crops are from the red varieties. Oats are sown from July to March. Those sown in July are twice as productive as those sown in the spring. White winter oats would prove quite as valuable as the favored red if more generally introduced. Red rust-proof oats are considered to be the best. Indian corn has been the main reliance for grain until the importation of the red rust-proof oat. The most popular field corn in South Carolina is gourd-seed. Dent's early is being introduced. Kaffir corn and Millo maize are being tried. We plant Indian and pop-corn and field peas in Marcb or April; barley and rye in November.

Vegetables: Spring plowing begins as soon after the 1st of January as is practicable. Turnips, parsnips, and carrots are planted in the fall; cabbage, collards, garden peas, beans, beets, salsify, and potatoes in the spring; in fact, all kinds of vegetables are planted here except celery and cauliflower; never knew them to grow successfully in this locality. All vegetables, early and late, with proper attention, will make two crops, and some three, in this climate.

Department seeds are sought after and always give satisfaction. The sowing of seed is not usually judiciously done, and in this climate all vegetables deteriorate after the second year. Northern seed for the Southern climate insures for the year choice vegetables. All imported seed of the root crops to be preferred.

TENNESSEE.

Grasses and forage plants: Blue-grass, red-top, orchard, timothy, clover, and herd's grass, and common red clover are grown more than any others. Other grasses are being rapidly introduced. Herd's grass and clover mixed make the best grass for grazing, and should be sown the 15th of November. Red clover grows to perfection. Japan clover grows all over the country and is valuable as feed for stock.

Amber cane is becoming more popular every year as a feed for mules and cows. The Russian sheep fodder (yellow lupin) proved a failure with us. A few farmers did their spring plowing in December last, and their crops are decidedly the best in the country. For hay, red clover, herd's grass, and timothy are chiefly used. Besides these there are large quantities of sorghum and German millet grown for winter feeding. Clover, timothy, and herd's grass are sown in February and March.

Grain: Winter wheat is sown from the 1st of September to the 15th of November. The varieties principally sown are the Fultz, Odessa, and Red May. German amber is also much liked. Red Mediterranean is also a favorite, and is not liable to damage from rust. Red and black oats are the favorite varieties, and are sown in February and March. Oats, if sown in October and not winter-killed, yield the best results. In Central Tennessee Indian corn is our principal crop, and is planted from April 1 to June 1. In the southeastern part of the State the farmers usually commence spring plowing for the corn crop about January 15. Corn planted in March gives the best results. Corn and cotton are the principal farm crops. Our corn is a general mixture, the white being used for bread and the yellow for stock.

Vegetables: All varieties of vegetables grow to perfection here. Central Tennessee is peculiarly adapted to the growing of corn and potatoes, both Irish and sweet. Turnips and onions produce good crops. Cabbage is uncertain. Peas, both garden and field, do well. Wethersfield onions, Flat Dutch cabbage, early and late purple-top, and white-globe turnip, Acme and Livingston tomato, perpetual lettuce, pole and Valentine snap beans are fine varieties. Morrowfat and early May peas are the best. Crook-neck squash is very early and of fine flavor.

TEXAS.

Grasses and forage plants: The cultivation of grasses in Southeastern Texas is very limited, most of them failures, until the introduction of Johnson grass from Alabama, which proved a great success for horses and cattle, and is considered equal to the best imported hay. It is not affected by drought; grows from 3 to 4 feet high. It is good where you want exclusively a hay farm. In Southern Texas we have a grass known as Texas-rye, which promises well as a winter and spring pasturage. It is hardy, standing the coldest weather, and would prove valuable for hay if properly managed. Grasses do not succeed in Western Texas on account of long droughts. The Bermuda succeeds only when planted on bottom-lands. Rye and sorghum afford fine green forage for hogs. Rescue-grass is a good variety for winter pasture.

Grain: In this climate the most successful farmers prepare their corn land in November and December, securing the benefits of light winter rains. Corn is considered the most valuable grain. Egyptian or dhoura is the most valuable, as it stands the dry weather remarkably well. It is difficult to procure the seed. Broom corn is a paying crop, yielding two crops per year. The second one is the better. In the northern section all wheat is sown in the fall. The White May and Mediterranean are the varieties that suffer the least from rust. Nicaragua wheat is a good variety. It averages 35 bushels to the acre. Both red and black oats are popular and superior in yield to other varieties. There is a great need of a rust-proof variety. Although peanuts are a paying crop, averaging $2 per bushel in market and yielding well, still they are but little grown.

Vegetables: All varieties of vegetables do well here when properly cultivated; the early varieties succeed best. Gardening is usually commenced about the 14th of

February, or as soon as the weather will permit. We can stand a drought here longer than in any other part of the world. Flat Dutch cabbage and drumhead, strapleaf and white globe turnip are considered good varieties. Tomatoes of all varieties do well, and melons are successfully grown.

VIRGINIA.

Grasses and forage plants: Alfalfa is splendid as a forage plant, and also for hay-making purposes. Under favorable circumstances it cannot be surpassed. It yields more to the acre than any other known grass. It should be cut three or four times during the season, or it will be too coarse and unfit for hay. Alsike is a fine grass for hay. It grows, under ordinary cultivation, from 2 to 3 feet in height. The blossom is so fragrant that it is a valuable honey plant. The meadow containing the clover was literally covered with bees from morning until night when in bloom. Two fine crops were produced during the season. Hay should be secured early enough in the season to allow the meadows a good start before the summer drought sets in, so that the roots may be well protected. This is not necessary with alfalfa, as its roots extend into the ground from 10 to 20 feet, where the soil is of a loose, calcareous character. Neither alfalfa nor alsike should be pastured until the fall rains set in. Care should be taken not to pasture too late in the spring.

Grain: From 8 quarts of seed wheat, sown on about one-sixth of an acre of land, nearly 6 bushels of the red Mediterranean wheat were harvested. The soil was a sandy loam, very deep, not very stiff, and was well adapted for the growth of alsike and alfalfa clover.

VERMONT.

Grasses and forage plants: Red-top is becoming quite popular. Farmers have found that it will grow and do well where timothy fails. The most popular corn for fodder is white Sanford; Stowell's evergreen sweet is also used.

Grain: White Russian wheat makes choice flour, and yields from 30 to 40 bushels per acre. Oats yield on good soil, if sown by the 15th of May, from 50 to 60 bushels per acre. Barley sown by the 15th will yield 40 to 45 bushels per acre.

Vegetables: All kinds of vegetables do well. Beans are an important crop in this State. Onions are largely raised for Eastern markets.

WASHINGTON TERRITORY.

Grasses and forage plants: Our grasses are blue-grass, red clover, alsike, timothy, and orchard grass. The climate is so mild that all the grasses named do exceedingly well. Five acres of red clover yielded 15 tons of splendid hay at one cutting. Could have cut nearly as much more, but preferred to use it for pasture, Most of the grasses here remain green nearly all the year. Timothy, with wheat-oats, and barley, is sown and cut for hay before ripe. We want grasses that will suit our alkali soil and long summer droughts.

Grain: Rye, wheat, and barley are the principal grains. Winter wheat is sown between the 15th of October and 1st of November.

Vegetables: All kinds of vegetables grow well except peppers, egg-plant, and other tender varieties. It rarely freezes deep enough to injure potatoes left in the ground.

WISCONSIN.

Grasses and forage plants: Grass yields in ordinary seasons from 1 to 2 tons per acre. Timothy, clover, red-top, millet, and Hungarian are the principal varieties.

Grain: Wisconsin is well adapted for growing all kinds of grain. Plowing is begun early in April for small grains; in May for corn. Corn, oats, and barley are the staple crops at this time. Burpee oats grow 6 feet high and are about ten days earlier than others sown at the same time. Surprise oats from the Department are earlier and larger and yield more than our native oats. Winter wheat is raised to a small extent. Stock farming is the main stay. Amber cane is not raised to any extent at present, as we have no sugar manufactories. The eastern part of Wisconsin is a fine section for wheat, oats, and barley.

Vegetables: The seeds received from the Department produced a fine crop. McLean's advancer was first and best, and Laxton's prolific peas did well and were of fine flavor. Corn and potatoes are the principal and most profitable crop. Onions are largely raised for city markets. Mangel-wurzel and rutabagas weigh as high as 13 pounds, beets 5 to 11 pounds, and cabbage 22 pounds. Cucumbers are a prolific crop. In fact, the yield of all kinds of garden vegetables is an abundant one.

In conclusion, I herewith append the following tabulated statement, showing the quantity and kind of seed issued from the Seed Division of the Agricultural Department, under the general appropriation act of Congress, from July 1, 1885, to June 30, 1886:

Description of seeds.	Varieties.	Senators, Representatives, and Delegates in Congress.	Statistical correspondents.	State correspondents.	Miscellaneous applicants.	Experiment stations and agricultural colleges.	Agricultural societies.	Grand total.
Vegetable	138	2,735,250	159,161	41,076	330,482	200	2,265	3,268,434
Flowers	132	273,535	....	....	63,901	....	....	337,436
Herbs	4	....	....	....	51	45	....	96
Tobacco	12	124,952	....	617	4,782	66	1,640	132,057
Tree	8	907	....	84	3,892	170	97	5,150
Sunflower	1	....	....	....	945	....	300	1,245
Opium poppy	1	....	....	....	13	....	....	13
Pyrethrum	1	....	....	....	175	46	....	221
White sage	1	....	....	....	920	....	....	920
FIELD SEEDS.								
Wheat	11	10,800	7,210	....	2,885	656	467	22,018
Oats	2	3,156	619	47	1,257	41	23	5,143
Corn	3	9,039	60	37	1,488	59	146	10,829
Barley	1	196	....	....	294	34	20	544
Rye	1	15	....	....	149	46	114	324
Sorghum	2	7,617	....	....	1,336	20	40	9,013
Turnip	12	339,684	50,142	23,485	5,615	493	12	419,431
Sugar beet	2	12,288	2,466	2,146	1,336	32	37	18,305
Mangel-wurzel	2	....	1,298	....	627	....	....	1,925
Grass	4	14,640	....	487	2,945	465	11	18,548
Clover	2	383	....	74	990	136	11	1,594
Millet	2	143	629	....	205	....	1	978
Teosinte	1	....	....	....	297	....	398	695
Forage plants, imported	7	....	2,401	....	922	322	975	4,620
TEXTILE.								
Cotton	6	5,503	468	389	640	40	36	7,076
Hemp	1	....	....	....	12	....	....	12
Jute	1	....	....	....	33	....	....	33
Ramie	3	....	....	....	59	....	446	505
Grand total	......	3,538,108	224,454	68,442	426,251	2,871	7,039	4,267,165

WM. M. KING,
Chief of Seed Division.

HON. NORMAN J. COLMAN,
Commissioner.

REPORT OF THE BOTANIST.

SIR: There is in agriculture a conservative tendency to follow in the beaten path of precedent. Hence it is that so small a number of plants are known in cultivation. Very few of the great mass of laborers can afford the time for and the risk attending experiments on a large scale, yet there are very few who cannot devote a little care to the trial of new plants, especially in localities where the ordinary kinds do not prove wholly satisfactory. For instance, the common red and white clovers came to us from Europe, and are almost the only kinds known in cultivation, whereas we have many native species which seem to have the qualities of hardiness, vigor, and size, which would probably render them valuable for the purpose of cultivation.

In those parts of the country where these clovers occur it would not be difficult for farmers or others to make an extended trial of one or more of such kinds, and report the result to this Department or to some agricultural paper for the benefit of others. As a help to such trials, we present herewith a paper on some promising native species of clovers, with such figures and descriptions as will serve to identify them.

As much loss and injury to crops result from the presence of pernicious weeds, as a guide to their recognition and destruction, we present a paper on some of the more important and common weeds of cultivated grounds, with instructions as to the means of eradicating them; this practical part of the information being from the pen of Mr. A. A. Crozier, the Assistant Botanist.

A history of the Division of Botany and an account of its work is also presented, for the information of the public and of all such as are interested in knowing what are its purposes and aims.

HISTORY OF THE DIVISION.

Soon after the completion, in 1868, of the building for the Department of Agriculture it was found necessary to have an experienced Botanist to complete the working force of the Department. It was recognized, also, that one of the first requisites for the use of the Botanist was a herbarium, in which should be represented, as far as possible, botanical specimens of all the plants of the country. An appropriation for a Botanist was made by Congress, and an arrangement was made between Hon. Horace Capron, then Commissioner of Agriculture, and Prof. Joseph Henry, Secretary of the Smithsonian Institution, by which the botanical collections then in the possession of that Institution were transferred to the Department of Agriculture as a beginning toward the formation of an herbarium. Those collections were chiefly made under various surveys and explorations of the Government, as those of Commodore Wilkes, those of the Mexican boundary, and of the Pacific Railroad surveys, together with large contributions from foreign Governments. To these have been since added the plants collected under the different Geological

Surveys, and large quantities obtained by purchase from various botanical collectors in different parts of the country, and important additions by exchanges and contributions.

The herbarium has now grown to be one of the largest and most valuable in the country, and contains a representation of nearly all of our 12,000 native phænogamous plants, as well as large numbers from Mexico, South America, and other countries. These specimens are a necessity to the Botanist, in order that he may be able to distinguish and determine the names of the plants which are constantly being sent from all parts of the country to the Department for determination and investigation. It is, in fact, a kind of reference library, to be consulted whenever occasion requires. Well prepared botanical specimens are for purposes of comparison almost as useful as the living plants, so that the herbarium gives nearly all the advantages of an arboretum and botanical garden, accessible at all times, and much fuller in species than it is possible to have a living collection. The rapid development of this vast country is constantly bringing to light new kinds of plants, respecting which information is sought, and which has to be obtained through the medium of the herbarium.

The herbarium is also often consulted by teachers and professors of science, who avail themselves of the opportunity here afforded of studying plants from all parts of the United States. This advantage is also participated in by educated foreigners, who, in visiting the capital of the country, expect to find centered here a full representation of its various productions. Natural history collections are a necessity of the present age, and every country of the world, which is advanced in intelligence and science, makes its capital the headquarters for information relating to its resources and productions, thus fostering that spirit of research to which the progress of the world is so much indebted.

EXPOSITION WORK.

In 1876 the various Departments of the Government were called upon to contribute toward making a suitable display of their functions and operations at the Philadelphia Centennial Exposition. As a proper representation of the work of the Botanical Division the Botanist made an extensive exhibit of large sections of the various kinds of forest trees of this country, embracing between 300 and 400 different species, brought from all portions of the Union, the largest and best display of the kind that had ever been made in the United States. This collection was afterward returned to the Department and subdivided into smaller sets, most of which were distributed to our agricultural colleges and institutions of learning, and to foreign Governments which desired them.

The division has also been called upon to assist in making displays at other important expositions, as at Louisville, Cincinnati, and New Orleans, particularly at the last-named city, where a large collection of the grasses of the United States was displayed, intended to show how extensive are the resources of the country in this important element of wealth.

WORK ON GRASSES.

Investigations of the grasses of the country have been conducted for many years by the Botanist, with the purpose of bringing to view and into cultivation new kinds which might prove useful additions to the

agriculture of the country. In connection with this subject several special reports on our native grasses have been published by the Department and distributed among farmers and others. The principal of these reports, called the "Agricultural Grasses of the United States, with their chemical composition," is a pamphlet of 144 pages, with 120 full-page plates.

Another, entitled a "Descriptive Catalogue of the Grasses of the United States," containing 110 pages, was published in connection with the grass display at the New Orleans Exposition.

Recently a special bulletin, or report of an investigation of the grasses of the arid districts of Kansas, Nebraska, and Colorado, has been issued.

There is yet urgent need for investigation of our native grasses, particularly in the line of thorough and protracted experiments, to determine their productiveness and adaptation to peculiar climatic conditions.

In a country so extensive as ours, embracing such a variety of soil, surface, and climate, it cannot be expected that any one kind of grass will be adapted to cultivation in all situations. But private experiments of the kind needed are attended with much expense, and very few persons have the means or the time to prosecute them. But it is in the power of the Government to conduct investigations which will probably result in greatly extending our agricultural resources and contribute to the happiness and wealth of the people. Particularly in the arid regions of the West new kinds of grasses are needed, adapted to the peculiar conditions there existing.

We present here, from a mass of correspondence, extracts to illustrate the nature of the inquiries which are constantly received by this Department.

A correspondent writes from Alabama as follows:

I find in this vicinity a grass growing about residences and along roadsides, in bunches and patches, the value of which I would like to learn more about. From the places where I find it it would seem to be an important grass just getting a start in our lands. It grows well under trees, and in the shade equally as well as in the open ground, and, owing to the number and strength of its roots, it grows in hard and dry grounds. I find it green now; after an unusually long drought, when almost all other grasses are burned up. Its rooting capacity is very great; a man can only pull up a small bundle with his hands. I wish to know what is the name of the grass, and its probable value as a grazing grass.

The grass referred to was the *Sporobolus Indicus*, described on page 50 of the "Agricultural Grasses of the United States," and figured on plate 50. It deserves attention from Southern farmers.

From Texas comes the following:

I send you herewith a package of grass for which I have no name. This grass I consider the most valuable of all the grasses that I am acquainted with. It is perennial and grows here all the year round, furnishing excellent green feed for stock at all seasons of the year, except that the green blades freeze in our very coldest weather, perhaps two or three times a winter, and then they grow out again in a few days. It increases rapidly from seeds, and also reproduces itself from suckers, which sprout from the nodes of the culm after the first crop of seeds ripens. I have seen these suckers remain green six or eight weeks after the old stalk was as dead and dry as any hay, and then they take root and form new plants. It grows well in all kinds of dry land. The plants from roots from one to two or three years old form large stools from 12 to 18 inches across and have very strong roots, and grow in the longest drought almost as fast as when it rains. I am anxious to prove which are the most valuable grasses for cultivation, because I am confident that they are destined to become one of our most profitable crops.

The grass mentioned was *Paspalum dilatatum,* which is highly

recommended for cultivation in the South. It is described in the "Agricultural Grasses of the United States," at page 24.

Another, writing from California, says:

I find that there is an intense desire among farmers here to obtain a grass capable of resisting the intense heats of our summers, and also, if possible, one that should grow on poor soil. There is no grass known here that will thrive through the dry summers and autumns, affording grazing for cattle during that period. If such could be had it would simply revolutionize California agriculturally, as many districts are fast becoming worthless for want of some such resource. This arises from the system of continuous wheat cropping, to which the land has been subjected for the last thirty years without relief from rotation of crops, so indispensable to proper farming.

A correspondent, of Lampasas County, Texas, writes:

The Texas blue-grass, which you recommended, I have found in my yard. I observed it closely last winter, not knowing what kind it was until it bloomed. Now it has spread, by means of underground stolons, until I have quite a quantity of it. I also found it growing luxuriantly in the Colorado bottoms, about 20 miles from here. It spreads very rapidly, almost equal to Bermuda or curly mesquite. This, I think, is just the grass I have been looking for. We want grasses that will take care of themselves, and I think Bermuda for summer and Texas blue-grass for winter will answer every purpose. Of native grasses we have two kinds that excel all others. One is *Buchlœ dactyloides*, known as curly mesquite, running mesquite, fine mesquite, and buffalo-grass. It is a good summer grass and fair for winter, as it is only partially killed by frost. The other grass is the *Stipa setigera*, known as bunch mesquite, winter mesquite, and big-bearded mesquite. It is, pre-eminently, the winter grass of a large portion of Texas, but of no value for summer. It is biennial, but usually thought to be perennial. This grass is found with the live-oak. For cultivated land Johnson grass, alfalfa, and Texas millet succeed well here. The Texas millet (*Panicum Texanum*) is undoubtedly the finest forage grass in existence. Horses, cattle, and sheep prefer it to any other kind of hay. It is a sure crop, and produces 2 or 3 tons per acre.

From Camden, Del., we have the following:

Inclosed please find a sample of what is here called an air plant. We have always been finding small patches of a few square yards in our clover fields, but that amounted to nothing, but in a lucerne patch it is very destructive. My own hay this year was absolutely unfit for bedding for stock. As the man who cut it remarked, you could stand at one end of the lot and move the grass at the other, so completely was it matted. I suppose it must have come in seed procured in California. How is the plant disseminated? What is it? Is there any prevention or remedy?

The plant spoken of above is a species of dodder (botanically, *Cuscuta*). It is a parasite, which first germinates in the ground and sends up a slender stalk, which attaches itself at once to green plants in its neighborhood, and thereafter draws its support from them by means of small suckers, which adhere closely to the surface. There are many species of dodder, some of which are parasitic upon only one particular kind of plant, as the flax dodder, the clover dodder, &c. In California there has been much trouble in fields of alfalfa from the presence of a kind of dodder, which, it is stated, was introduced with alfalfa seed from Chili, and this is probably the kind above complained of. The only prevention of the pest is to make sure of sowing only pure seed. The cure, when it gets into a field, will consist in cutting the crop before the dodder matures any seed, and repeating the process as long as the dodder makes its appearance.

From Chicago, Ill., comes the following inquiry:

I have heard of a strong-growing beach-grass that they have used with success in staying the shifting sand-dunes in the north part of Germany and Holland. We have some similar land at the south end of Lake Michigan on which we would like to experiment, if we knew the kind of seed and where to get it; something with strong roots, that would grow in pure sand, surviving strong winds and winter storms, would be a blessing to a large section of this country.

There are several grasses employed in Europe for the purposes above indicated, but chiefly the one which is botanically called *Ammophila arundinacea.* It grows on the seacoast in Europe, and also in North America. It has no agricultural value, being quite too coarse for food for cattle. But the widely creeping and matted rootstocks serve to bind the sands and resist the encroachment of the waves. This grass has also been used at Provincetown, or Cape Cod, for the above purpose, and the harbor at that place was long preserved from destruction by the care which was taken in setting out this grass, through a committee appointed for that purpose.

A correspondent from Walsh County, Dakota, says:

The question of what is the best variety of grass to replace the native grasses, which are fast disappearing in this country, is one of vital importance to us. Clover has been a failure with us thus far; the frost destroys it so effectually that not a blade can be seen in the spring. Timothy has been only partially successful; a fair crop has been obtained the first year, but the second year it appears to get choked out by weeds and foul stuff. What we need is some variety that will stand the severe frosts of winter, produce a good crop of hay, and make a good, permanent pasture.

There is a very great and important necessity, not only for Dakota but for many other portions of the country, that experimental stations should be established for the testing of all kinds of grass and forage plants, in order to obtain such for cultivation as are proven to be adapted to the existing circumstances.

From Uvalde, Tex.:

Inclosed find a stalk of a wild grass which has made its appearance in Western Texas within a few years. It is a perennial grass, comes up in early spring and matures about the middle of May. It seems to be adapted to this dry climate.

This is a native grass, growing in most of the Southern States, in Texas, and extending west to California. In California it is known as California timothy, but is not there esteemed of much agricultural value. In the Southern States it has been cultivated to some extent, and is known in some localities as Gilbert's relief grass. Doctor Phares says that Mr. Stewart, of Louisiana, prefers this grass to others which he has tested, for quantity and quality, for winter and spring grazing, and for soiling for milch cows. There is much favorable testimony respecting the grass in the South, and it is deserving of extended cultivation.

Again, from Texas:

We send you this day, by mail, a bundle of grass. It is a true winter grass, coming up with the fall rains in October and November; is fine pasture all winter for horses, cows, sheep, hogs, &c. No freeze affects it here whatever. Seed ripens in April; it dies in May, and remains so until fall. Stock do not seem to relish it much until after frost. It forms a very thick mat or sod, and is spreading fast over our grounds. It kills out weeds that usually come up in the spring. Such a grass is worth millions to Texas for winter pasturage.

This is *Bromus unioloides*, which is sometimes called rescue grass, or Schrader's grass. A full account of it is given in the "Agricultural Grasses of the United States." Respecting this grass also another Texas correspondent says:

Inasmuch as Western Texas is the great stock-raising section of the Southwest and considering the fact that pasturage is scanty, particularly in February, thus stunting the growth of young cattle, this grass seems wonderfully adapted to supply just what is greatly wanted, both for milch cows, calves, colts, and ewes; and, besides, it grows well on the thinnest soil and crowds out weeds, while not interfering with the native mesquite. I therefore regard it as a wonderful and most important discovery.

From Putnam County, Arizona, we have the following:

This country contains millions of acres of land that seems adapted to no other earthly purpose than grazing, but the grass is so thin upon the ground that it takes many acres to maintain one cow, and cattle must be distributed very thinly along the water-fronts in order to have them thrive, because when feed is scarce they are obliged to travel too far, and are, consequently, poor in flesh and stunted in growth, whereas if all the land was well seeded to thrifty grass the same land could maintain three times as many cattle. We want to know if there are not some kinds of imported grasses that are good for our purpose, and that will grow in our climate, between 32° and 35° north latitude on the Pacific Slope. There is in this latitude rain only twice a year. The land is fertile, but lacks the proper kinds of grass to furnish sufficient pasturage. Are there not some kinds which might be imported from Arabia, or some country with a similar climate, which would be an improvement?

There are millions of acres of arid lands, of the character of the above described, for which the great need is the establishment of experiment stations in the arid districts, where many kinds of grasses and forage plants could be thoroughly tested on a large scale and under skillful and intelligent managers. Such experimentation would, undoubtedly, result in important practical benefits.

A correspondent, of Taylor County, Texas, writes as follows:

I have a body of land lying north of Fort Worth, in the black, sandy soil, also another in the Panhandle country, along the Upper Red River, among the red lands, which I am improving for agricultural and stock-raising purposes. I desire to obtain information as to what are, or would be, the best grasses for these regions, as the short, curly mesquite and sedge-grasses which abound, while being very nutritious are not of sufficient growth, and are not suitable for hay-making, nor will they support the number of stock to the acre that the soil would warrant.

Such inquiries as the above can only be partially answered at the present time for the want of proper investigations and experiments. By devoting a portion of the land to the cultivation of summer crops of such grasses as Hungarian, Texas millet, and sorghum it could be made safe to keep twice the quantity of stock. At the same time experiments should be made with permanent grasses, such as Johnson grass, Texas blue-grass, orchard-grass, and any others that give promise of utility, including even some of the thriftier and more productive native grasses of the region, as blue-joint and some of the *Panicums*.

From Savannah, Ga., we have the following:

In your "Descriptive Catalogue of the Grasses of the United States," page 11, it is stated that *Panicum maximum* (Guinea-grass), seldom matures seed in this country, and is usually propagated by division of the roots, and that it is too tender to be cultivated, except in the very warmest portions of our country. Doctor Phares, in his valuable book of grasses, states that whenever it has had proper care the crop is enormous, and in Jamaica, where it is cultivated extensively, it is held next to sugar in value of crop, and that the roots are easily killed by frost and must be protected in winter. For the information of your Department I beg to state that specimens of this grass have been growing in a garden here for several years; that the roots are uninjured by our frosts, and that the plants have borne seeds freely, and have been extensively propagated from these seeds.

Probably this valuable grass will prove hardy in the southern portion of the Gulf States and throughout Florida.

A correspondent from Missouri sends a specimen of plant, and says:

This morning a gentleman brought me a sample of a plant he found in a garden here that he suspects to be the Canada thistle. I inclose it for your inspection. We have considerable excitement about the Canada thistle, as many farmers are afraid it will get introduced. We have a law against allowing it to grow, and I am the prosecuting attorney, and wish to have information in regard to it.

In this case the plant sent was what is called sow-thistle, an annual spiny-leaved plant, but easily killed, and not inclined to spread.

The introduction of the Canada thistle may well be dreaded in any agricultural district.

From Inyo County, California, a correspondent writes:

Our cattle often eat something that is poisonous, and I am inclined to think that the plant I send herewith is that which poisoned them. The cattle swell up and die soon after eating the poison.

The plant sent was a species of *Cymopterus*, of low growth, akin to what is called poison parsley, but of its properties we know little. The same kind is frequently sent from Idaho and Wyoming, with the same complaint of its poisonous character. It makes its appearance early in the spring, before grass has become plentiful, and cattle eat it from hunger and not from choice. It is so abundant that its extermination would be difficult. If cattle were well provided with hay or fodder they probably would not touch it. Probably it produces *hoven*, like the effect of over-feeding on green clover.

From Bakersfield, Cal., comes the following respecting a poisonous plant known there as "loco":

It prevails quite abundantly over an extent of 150 square miles in this valley, and, I am informed, is found in other valleys of the State, and also in Arizona. This year the army-worm and a minute insect, which destroys the seeds, have killed a great deal of it; but, if not molested, it will soon flourish to as great an extent as ever. I think very few, if any, animals eat the loco at first from choice; but, as it resists the drought until other food is scarce, they are at first starved to it, and, after eating it a short time appear to prefer it to anything else. Cows are poisoned by it as well as horses, but it takes more of it to affect them. It is also said to poison sheep. As I have seen its action on the horse, the first symptom of the poisoning is hallucination. When led or ridden up to some little obstruction, such as a rail or bar, lying in the road, he stops short, and, if urged, leaps as though it were 4 feet high. Next he is seized with fits of mania, in which he is quite uncontrollable, and sometimes dangerous. He rears, sometimes even falling backward, runs or gives several leaps forward, and generally falls. His eyes are rolled upward until only the white can be seen, which is strongly injected, and, as he sees nothing, he is as apt to leap against a wall or a man as in any other direction. Anything that excites him appears to induce the fits, which I think are more apt to occur when crossing water than elsewhere, and the animal sometimes falls so exhausted as to drown in water not over 2 feet deep. He loses flesh from the first, and sometimes presents the appearance of a walking skeleton. In the next and last stage he only goes from the loco to water and back; his gait is feeble and uncertain; his eyes are sunken, and have a flat, glassy look, and his coat is rough and lusterless. In general, the animal appears to perish from starvation and constant excitement of the nervous system, but sometimes appears to suffer acute pain, causing him to expend his strength in running wildly from place to place, pawing and rolling, until he falls and dies in a few minutes.

We invite further information from those acquainted with the plant and its poisonous qualities.

The plants sent were those of *Astragalus lentiginosus*, locally called "rattle-weed" and "loco." It belongs to the order *Leguminosæ*, and is somewhat similar to lucern in appearance, and produces bladdery pods, in which the seeds rattle when ripe. Hence the name "rattle-weed."

In Colorado and New Mexico the same disease among horses and cattle is produced by the *Astragalus mollissimus* and other allied plants. The losses of stock from the eating of these plants has been very great.

From Wellborn, Fla.:

Inclosed I send you, for identification, a forage plant called here "beggar-weed." It is a nuisance in our cotton fields, yet all our planters are anxious to get it into their fields. It grows from 1 to 6 or 8 feet high. All kinds of stock eat it with greediness and fatten on it, and can work daily with nothing else. It has large, spreading roots, and I think it would enrich the ground as much as clover if plowed under. Persons sometimes go 20 miles to strip the seed to get a start.

This plant is a species of *Desmodium*, several kinds of which grow throughout the country, and are commonly called "beggar-lice," from their appearance and from adhering tenaciously to the clothing of passers-by. The species sent would not probably be hardy in the Northern States.

From Gainesville, Fla.:

Vanilla beans are quoted in New York at from $7 to $12 per pound wholesale. Can you inform me if the climate and soil of Florida are adapted to their growth?"

From Tucson, Ariz.:

During the past year I have discovered tobacco growing wild in the mountains of Arizona. Have you any record of the existence of wild tobacco in this region?

Several species of wild tobacco were cultivated by the Indians. One species (*Nicotiana rustica*) was cultivated by the Indians in New Mexico and Arizona, as observed by Dr. Ed. Palmer. Another species (*Nicotiana quadrivalvis*) was cultivated by the Indians from Missouri to Oregon. One or two other species are recorded as having been cultivated in California.

From Philadelphia, Pa.:

I wish to utilize a strong, white fiber which is furnished by the plant called "bear-grass," which grows in the Southern States. To do so economically and profitably requires that the plant should be found in large quantities in some particular locality. Can you inform me of any place where it grows in sufficient quantity for that purpose?

From Savannah, Ga.:

Can you give me the botanical name and description of the inclosed plant? It grows in a wild state in Brooks County, Georgia, and is known among the negroes as "poor man's salve," and a wonderful efficacy is claimed for it in curing old sores and indolent ulcers.

The plant is a species of *Croton*, which grows commonly in the Southern and Western States.

From Norfolk, Va.:

I send a few cork-oak acorns, grown on a tree produced from an acorn planted about 1860 or 1861. The original acorns came from Washington Patent Office, I think, and being planted just before the war were neglected, and only three of the five have lived, and they being too close together to develop. The largest tree is about 14 inches in diameter and about 20 feet high. This is the first year I have ever seen acorns. The cork is about 1½ to 2 inches thick, and too porous for use.

A large quantity of these cork-oak acorns were distributed in the Southern States about the time mentioned above and many of them grew. Reports concerning such have been received from South Carolina and Georgia, where trees are probably still growing. No bark has yet been produced of sufficient thickness and compactness to be serviceable for the manufacture of corks.

From Titusville, Fla.:

I send you a package containing a plant that is said to be the best known specific for dysentery and all bowel complaints. It is said to be an old-time remedy in the Southern States. It is called "flux-weed." I will be thankful if you will give me the name and medical properties of the plant.

This is *Galium hispidulum*, a low, spreading plant of the order *Rubiaceæ*. We have no knowledge of its medicinal properties.

From Texas:

I inclose a plant called "Indian blood-weed." Please identify and classify for me. It grows mostly along the foot of the "red hills" (which are ranges of flat hills containing iron). It was used by the Indians for purifying the blood and curing skin diseases. I have seen it used by the settlers and herders, who made a tea of it, which in all cases proves beneficial in curing sores or skin diseases in a short time.

The plant referred to is a species of *Ephedra*, a singular looking, leafless, or nearly leafless, shrub, growing in the southwestern arid districts. It is a popular remedy in those regions, and probably has active properties.

From West Virginia:

I send you a specimen of shrub which grows in mountainous situations in this State, and which is called mountain-tea. It is used as a substitute for ordinary tea of commerce, and is said to be as pleasant and agreeable to the taste as that article. Please inform me of its botanical name.

The plant is botanically called *Comptonia asplenifolia*, growing abundantly in the Northern States, where it is called "sweet-fern." There are a number of other substitutes for tea employed in different parts of the country, as, *Ceanothus americanus*, or New Jersey tea; *Sida stipulata*, a small malvaceous plant; *Ilex cassine*, the black tea of South Carolina, and others.

From Burnet County, Texas:

This day I send you by mail a species of a grass which is our best forage plant for winter pasture. It grows rapidly all winter, and is ready to go to seed in April. Stock of all kinds are very fond of it. It is never killed or even injured by cold in the winter. The seeds are large enough to be ground, and probably would make good breadstuff. Please let me know the name of the grass.

The grass is *Bromus unioloides*, a native of Texas and the Southwest, and is undoubtedly one of the most valuable of grasses for winter pasturage in that region.

From an Army officer in Montana, transmitted by the Quartermaster-General:

I have the honor to send herewith samples of a weed found among the wild-grass hay delivered here under current contracts. In small quantity it appears to do no harm, but when present in greater amount among hay cut in creek bottoms, particularly in swampy spots, it causes griping and spasmodic action in the legs, followed by looseness in the bowels and general weakness. Mules and horses avoid eating it as much as possible, but farmers assert that cows do not mind it and eat it with impunity. I would be glad to have the name and character of the plant determined.

The plant sent with this communication proved to be *Smilacina stellata*, a common plant in mountainous regions, especially in the Northern States and Rocky Mountains. It is related to the *Convallaria* or the lily of the valley, so called in cultivation. We have no previous record of the peculiar properties noted in the above instance.

From Ennis, Tex:

Inclosed we send you a twig of a shrub which abounds on some of the hills of Central Texas, and is commonly known as prickly currant. As you will observe, it resembles holly, and we think it must belong to the same family. Will you kindly determine its botanical name, and let us know at your earliest convenience?

The specimen sent belongs to a species of barberry peculiar to Texas and the Southwest, the botanical name of which is *Berberis trifoliata*. The leaves are thick and spiny-toothed, somewhat like the holly, but much smaller. The bush, which is 3 or 4 feet high, is very spiny, and has bunches of red fruit somewhat like the currant in appearance.

From Fremont County, Wyoming:

Please let me know if you have or if there is any grass seed such as will grow in this climate. The climate is dry and the altitude high, and in the summer months there is a scarcity of water; consequently we cannot raise hay, and wild grass, by being pastured so much, seems to grow shorter every year. The soil is good, but sandy. We want a grass that will grow in such a climate and make a good hay, even by irrigating in the spring as long as water lasts.

From a seed-merchant, Chicago, Ill.:

Kindly name the inclosed specimen, and let me know what it is as soon as possible.

From Spartanburg, S. C.:

I send you herewith a pod of a plant growing in this State having an abundance of fine, silky hairs attached to the seed. I would like to know if this fine delicate fiber can be utilized in any way. I think the plant also possesses medicinal properties, and would be glad to know if such is the case.

The pod belongs to a kind of milkweed, botanically called "*Asclepias tuberosa*," or, popularly, "pleurisy root," because it is employed in cases of pleurisy and other diseases. The silky fibers of the seeds are like those of all the milkweeds, of which there is a large number of species, and the inquiry as to its economic use is often made; but, although very delicate and beautiful, it lacks tenacity, and cannot be spun by itself into a thread.

From Florida:

We are alarmed here at the appearance in our fields and orange groves of what is called "nut-grass," and which bids fair to double our labor in cultivation. Tearing up by the roots and even sifting the soil have proved of no avail in getting rid of it. May I beg that you will indicate as soon as possible the best and quickest means for its destruction?

The nut-grass, or coca as it is also called, is one of the worst pests of agriculture in the South. The botanical name is *Cyperus rotundus*. Mr. Elliott, in his "Botany of South Carolina and Georgia," says of this sedge:

It is becoming a great scourge to our planters. It shoots from the base of its stem a threadlike fiber, which descends perpendicularly from 6 to 18 inches, and then produces a small tuber. From this horizontal fibers extend in every direction, producing new tubers at intervals of 6 to 8 inches, and these immediately shoot up stems to the surface of the earth and throw out lateral fibers to form a new progeny. This process is interminable, and it is curious to see what a chain or network of plants and tubers can with some care be dug up in loose soil. The only process yet discovered by which this grass can be extirpated is to plow or hoe the spots in which it grows every day through a whole season. In their perpetual efforts to throw their leaves to the light the roots become exhausted and perish, or if a few appear the next spring they can easily be dug up. This experiment has been successfully tried by John McQueen, esq., of Chatham County, Georgia.

This account was written more than sixty years ago. The method given for destroying the pest is applicable to the present time, and is perhaps as good as any one known.

From editor of the Courier-Journal, Louisville, Ky.:

Inclosed we hand you a specimen of a plant received from a correspondent at Salem, N. C. Please name it for us, and give any information which there may be about it of any special interest.

From the commissioner of agriculture for Georgia:

I will be obliged to you if you will name the grass of which I inclose a specimen, stating its economic value. The grass grows in bunches in fence corners, stems from 5 to 7 feet high, leaves from 8 to 12 inches long. It is sent to me from Washington County in this State.

FOREIGN INQUIRIES, ETC.

From the Government Botanical Gardens at Saharamper, Northwestern India:

I am just now studying the grasses of Northern India with special reference to their relative value for forage or fodder, and as many of our best kinds occur also in America, the information given in your book ("The Agricultural Grasses of the

United States") is of very great value. In Upper India we have extensive tracts (called usar land) devoid of cultivation, owing to an excess of saline ingredients in the soil (salts of soda). There are two or three kinds of grass which apparently thrive in such soil, one of which, called "usar grass" (*Sporobolus tenacissimus*), represents the only vegetation over extensive areas of this usar land; the other grasses which affect usar in less abundance are *Eragrostis ciliaris* and *E. cynosuroides*. The *Sporobolus* appears to be a good fodder grass, as it is greedily eaten by cattle. I can not help thinking that it would be well worth while trying to introduce from other countries any species known to thrive in saline soil, and I should be extremely obliged if you could put me in the way of obtaining the seed of such kinds.

The usar grass above referred to is, according to a figure of the plant in "Illustrations of the Forage Grasses of Northwestern India," very closely related to our *Sporobolus cryptandrus*, which abounds on the arid plains of the West.

From Timaru, New Zealand:

Noticing in an Australian paper an account of some of your native grasses, which would seem to be desirable to add to present varieties in New Zealand, I take the liberty of writing you upon the subject. Unfortunately our native grasses are nearly all delicate, fine annuals, which disappear before heavy stocking. The prevailing grass or tussock (*Poa australis*) is a wiry, hard grass, that yields no feed except when burned in spring and the tender, green shoots spring up. Thereafter it becomes a hard, wiry bunch-grass, that sheep never eat, and seems to serve for shelter to the finer sorts. There appears plenty to eat, but sheep do not touch it unless starvation drives them. Cultivation has driven out the native grasses, and those sorts common to England are in use here. We want varieties which might thrive here. The only one yet that does is Kentucky blue-grass.

From Prussia, Europe:

I have for a number of years been experimenting with various plants at the Agricultural Institute of the Halle University, and would like to do the same with the native buffalo-grass of the United States, which is illustrated and described in the Annual Report of the Commissioner of Agriculture for the year 1880. I have not been able to get the seed in Europe.

RELATION TO OTHER BRANCHES OF THE DEPARTMENT.

The natural sciences are intimately related to and dependent on each other. The plants which are the care of the Botanist are often subject to the destructive depredations of insect foes, and the aid of the Entomologist has to be obtained to learn the name and history of such insects. Again, the Botanist and the intelligent cultivator of plants find that insects have much to do with the fertilization of plants, and that without their aid, in many cases, the production of fruit would be much diminished or entirely fail; in other words, success in certain crops is largely dependent on the good offices of these insect friends. In such instances as these botany and entomology come into close connection.

The Chemist is often required to make an analysis of plants or vegetable products having medicinal or poisonous properties, and he finds it important to know the name, botanical character, and affinities of such plants or products, and for that purpose calls in the aid of the Botanist. The Ornithologist may be pursuing investigations into the food habits of birds to ascertain which are granivorous, and which are insectivorous. He finds that he needs the assistance of the Botanist in identifying the seeds and grains which he finds in the stomachs of his birds.

Thus each division of the Department is an aid to the other, and the development of each is required not only for its own work, but also for the aid which it may furnish the others. The following statement

from the Division of Entomology indicates how botany aids that science:

Very frequently insects are sent to the Division of Entomology for determination and report, accompanied by specimens of their food-plants. The latter are frequently in a fragmentary condition, and when known to the sender are known only by some local name. In such cases as this it is our custom to consult the Botanist, and the information which we obtain from him is of material aid to our own division. The two divisions are, in fact, closely related in their work.

The Chemist states as follows:

The relations of the Botanical to the Chemical Division are of the most important nature. A large part of the plant material which is sent to the Chemist must be accurately identified by the Botanist before being submitted to analysis, in order that there may be no doubt as to the exact species examined. The data are thus preserved for the future and accurately fixed as relating to some particular plant On the other hand, this identification prevents the repetition of an analysis, by making it possible to search for previous analyses of the known species in hand.

In studies of the adaptability of plants to climatic condition the Chemist and Botanist work hand in hand, and in all the analytical investigations which are undertaken by the Chemical Division the confidence that their results are applied in the right places is due to the certainty derived from the identifications of the Botanist.

As an example of the manner in which the two divisions work together may be cited the studies at present being made of one of the prickly pears of Texas, which is attracting attention as of value for stock. The Botanist's knowledge as to the growth and distribution of the plant and his observations of its habits of growth are a necessary complement to the chemical study of its food value.

With an increased force the fields which the Botanical Division might enter in conjunction with the Chemical would be numerous.

The relations of the Botanical to the Seed Division are becoming increasingly important. In the purchase of seeds for distribution the Botanist's knowledge of the natural habits of a plant is essential to the determination of its probable agricultural value. Some of the native grasses investigated by the Botanist have been introduced into cultivation through the Seed Division, and further work of the kind is needed to supply the demand for grasses adapted to different parts of the country. Every year the aid of the Botanist is required to determine the purity of seeds purchased by the Seed Division for distribution.

The relation of the Botanical to the Horticultural Division is too obvious to require mention. The greenhouses and grounds are a constant source of supplies to the herbarium, and each division is an aid to the other in many ways.

INVESTIGATION OF FUNGOUS DISEASES.

At the last Congress an appropriation was made for the investigation of the fungous diseases of plants, such as mildew, smut, blight, grape-rot, potato-rot, &c., and for experiments necessary to determine suitable remedies for those diseases. The mycological section has accordingly been organized, and is conducting investigations in this line of work which will, it is hoped, result in great good, by preventing the immense losses which farmers and horticulturists are subject to by the frequent occurrence of those diseases. Special bulletins on the subject will be published for general distribution.

DIRECTIONS TO CORRESPONDENTS.

In order that the division may be more useful to those who consult it, the following directions regarding plants for identification are inserted. Plants are often received by the Botanist for name in so

imperfect a state that the desired information cannot be given. Additions to the herbarium are constantly being made of even ordinary plants, for the purpose of exchange, &c., and when not of further use to the sender specimens sent are often added to the herbarium, and it is desirable to have them suitable for the purpose.

PERFECT SPECIMENS.

Not every plant can be recognized at sight even by botanists; but any plant which has been described and named can be identified if perfect specimens are furnished. In the case of new plants, which are still occasionally found, it is especially important to have good specimens, in order that they may be classified and named.

Sometimes perfect specimens cannot be obtained at the time information is wanted. In such cases whatever can be had may be sent and may prove sufficient, but as full a description as possible should be given of the parts not obtainable.

A perfect specimen includes all parts of the plant or samples of all parts, though some parts are more important in identification than others. The flower is the part usually most essential; any other part can better be wanting than this, and in most cases this is furnished. With all plants, however, the fruit is also important, and many cannot be determined without it. Dry fruits require less care in preparation than flowers, are less likely to be injured, and are more easily examined. Notwithstanding these facts, the specimens received at the herbarium from both botanists and others are much more frequently defective in the fruits than in the flowers. The leaves are always important and are seldom omitted, but inmany herbs the radical leaves, or those from the base of the stem, differ in form from the others, and these are not always furnished.

In some plants certain parts are more important for identification than the same parts in other plants. With herbs it is important to know whether they are annual, biennial, or perennial. To determine this requires the root as well as stem. If this is not furnished, the duration of the plant should be stated. With sedges it is essential to have the full-grown fruit, though desirable to have the flowers also. The habit of growth in sedges, whether singly or in tufts, is a distinctive character, which the specimens should show. With grasses it will usually be sufficient to gather specimens soon after flowering, though if some be in flower and others ripe it is better. The difficulty with fully-ripe grasses is the liability of the seeds and chaff to scatter. The rooting portions of grasses should also be furnished, as this is especially important in determining their agricultural value.

PREPARATION OF SPECIMENS.

It is not necessary to have living specimens for identification. Properly dried plants are nearly as good. They can be more easily and safely transported, and may be examined at any time. If dried quickly under pressure, in the manner of herbarium specimens, they retain essentially their original shape, something of their color, and do not become brittle, as when dried in the open air.

In drying, the plants should be placed between folds of absorbent paper (newspaper will answer) and subjected to a pressure of 25 to 50 pounds, according to nature of the specimens and the amount under pressure. As the papers become damp the plants should be removed

to fresh ones. This should at first be done as often as once a day. If considerable paper is used the plants will require to be changed less frequently and will be less likely to become discolored if neglected.

Plants should be gathered when dry, and preferably in dry weather. In the collection of specimens botanists commonly carry drying papers into the field and place the plants in them as soon as gathered, holding them in place by straps. When this is not convenient a tin collecting case is often used, which keeps the plants from wilting until they can be placed in the drying papers. A very good substitute for such a case is ordinary paper, in which the plants may be wrapped as gathered. In placing the plants in the papers to dry, have but one kind on a sheet, and place with it at once a label bearing the date and place of collection, with the name, if known, and any other particulars desired. Fleshy plants will need to be divided to dry properly, and thick specimens to prevent them occupying too much space. Seeds may be placed in an envelope and deposited with the remainder of the plant.

SOME NATIVE CLOVERS.

There are in the United States 40 species of native clovers (*Trifolium*).

The larger number of these belong to the Pacific side of the continent, and to Utah, Idaho, and Montana; a few species belong to Texas and the Southern States, two or three of which extend northward in the States adjacent to the Ohio and Mississippi Rivers.

None of our native species have been cultivated so far as is known, although several of them are of as large and vigorous growth as the common red clover, and are worthy of trial, as they may prove better adapted to some soils than that species. We give descriptions and figures of the most promising ones, and suggest that in the sections where they grow they should be subjected to experiment.

Trifolium fucatum.

This is one of the largest and strongest growing of our native kinds, and is found on the Pacific coast. Under favorable circumstances it attains a height of 2 to 3 feet. The stem is decumbent, smooth, thick, and juicy. The stipules at the base of the leaf are half an inch to an inch long, ovate, broad, and clasping the stem. The leaves are trifoliate, with stems or petioles 3 to 6 inches long; the leaflets vary from roundish or oblong to obovate, thickish, strongly veined, three-fourths of an inch to an inch and a half long, and with numerous small, sharp teeth on the margins. The flower heads are large (1 to 2 inches in diameter), larger than those of the common red clover on naked peduncles (stems), which are longer than the leaf-stalks (sometimes 5 to 6 inches long). There is a conspicuous green involucre surrounding the base of the flower head deeply divided into 7 to 9 ovate, entire, and pointed lobes, which are about half as long as the flowers. The heads contain comparatively few flowers (about 8 to 10), but these are about an inch long, thick and inflated, the calyx about one-fourth as long as the corolla, which varies from pink to purple in color. Mr. S. Watson, in the "Botany of Calfornia," says of this: "A common species in the Coast Ranges and in the foot-hills of the Sierra Nevada through the length of the State—in some places very abundant and affording good pasturage." It would seem very desirable that this species should be given a fair trial in cultivation. (Plate I.)

Trifolium megacephalum (Large-headed clover).

A low species, seldom reaching a foot in height, but robust and with strong, deeply penetrating roots. A number of stalks usually proceed from one root, but these stems are unbranching, somewhat hairy, and terminate with a single large head. The leaves mostly proceed from the base of the stem, there usually being but one pair on the stalk near the middle. The lowest leaves are long-stalked, and with 5 to 7 leaflets instead of 3, as in most clovers, but the upper ones are sometimes reduced to 3 leaflets. The leaflets are an inch long or less, somewhat wedge-shaped or obovate and blunt at the apex, and with very fine, sharp teeth on the edge. The stipules at the base of the leaves are large, mostly ovate in form, and sharply toothed or deeply cut. The heads are mostly terminal, about 1½ inches long, on a naked peduncle, and without an involucre. The flowers are large, purplish, about an inch long, and very compact and spicate in the head. The calyx, with its long, plumose teeth, is half as long as the corolla. This species grows in the mountain region of California, Oregon, Washington Territory, Nevada, and Montana. It is not as large as the common red clover, but experiments are needed to determine its possibilities for pasturage. Its large, showy heads and its peculiar leaves would make it an interesting ornamental species. (Plate II.)

Trifolium involucratum.

This is an annual species, presenting a great variety of form, but under favorable circumstances reaching 1½ or 2 feet in height and of vigorous growth. The stems are usually decumbent and branching below, very leafy, and terminating with 1 to 3 heads on rather long peduncles. The leaves are on stalks longer than the leaflets, which are in threes, one-half inch to an inch long, of an oblong or obovate form, smooth, and with very fine, sharp teeth on the margins. The stipules are large, ovate, or lanceolate, and usually much gashed or deeply toothed. The heads are long-stalked, about an inch long, the purplish flowers closely crowded, and surrounded with an involucre, which is divided into numerous long-toothed lobes. The flowers are half to three-fourths of an inch long, slender, with a short, striate calyx, the teeth of which are very slender, entire, and pointed, and little shorter than the corolla. This species has a wide range of growth in the western part of the continent, prevailing from Mexico to British America through the mountain districts. Under cultivation it would probably produce a good yield of fodder, but has never been subjected to experiment so far as known. (Plate III.)

Trifolium stoloniferum (Running buffalo clover).

This is a perennial species, growing about a foot high; long runners are sent out from the base, which are procumbent at first, becoming erect. The leaves are all at the base, except one pair at the upper part of the stem. The root leaves are long-stalked, and have three thinnish obovate leaflets, which are minutely toothed. The pair of leaves on the stem have the stalk about as long as the leaflets, which are about 1 inch long. The stipules are ovate or lanceolate, pointed, and entire on the margins, the lower ones nearly an inch long, the upper ones about half as long. There are but one or two heads on each stem at the summit, each on a peduncle longer than the leaves. The heads are about an inch in diameter, rather loosely

flowered, each flower being on a short, slender pedicel, or stem, which bends backward at maturity. Each flower has a long-toothed calyx about half as long as the corolla, which is white, tinged with purple. This species is found in rich, open wood-lands and in prairies in Ohio, Illinois, Kentucky, and westward. It is smaller in size and less vigorous in growth than the common red clover. (Plate IV.)

Trifolium Carolinanum (Southern clover).

A small perennial clover, having much resemblance to the common white clover. It usually grows from 6 to 10 inches high, somewhat pubescent, the stems slender, procumbent, and branching. The leaves are trifoliate, on petioles of variable length. The leaflets are about half an inch long, obovate, wedge-shaped at base, and somewhat notched at the summit. The stipules are nearly as long as the leaflets, ovate or lanceolate, and slightly toothed above. Each stalk has usually two long-stalked heads, proceeding from the upper joints. The roundish heads are from one-half to three-fourths of an inch in diameter, without an involucre, and with numerous crowded, small flowers on slender pedicels, which become reflexed in age. The long lanceolate teeth of the calyx are slightly shorter than the small, purplish, pointed corolla. The pods are usually four-seeded. This species occurs in all the Southern States and in Texas. It is too small to be valuable for fodder, but is worthy of trial as a constituent of pastures in the South. (Plate V.)

WEEDS OF AGRICULTURE.

The majority of our most troublesome weeds are plants introduced from other countries. As a locality becomes cleared up and brought into cultivation the character of the spontaneous vegetation always undergoes marked changes. Many of the native plants disappear, others become more abundant, and new plants introduced from foreign countries, or other parts of the same country, frequently become the prevailing vegetation.

Owing to the conditions of modern commerce and the natural provision for their distribution it is practically impossible to long exclude outside weeds from any considerable district. The weed laws of various States have done much to call the attention of agriculturists to the most troublesome weeds, and have in many cases retarded their introduction and distribution, but it is not to be expected that through any agency our worst weeds will become so subdued as to require no further attention. An account like this can only furnish the means of recognizing some of the more pernicious ones, and give some account of their origin and methods of propagation, with suggestions for keeping them in check or eradicating them for a time.

If the plants troublesome in cultivated crops were only such as were always and everywhere recognized as weeds, the question would be much simpler. Unfortunately many of our worst weeds were first introduced as useful plants. A large number have escaped from flower gardens, as Indian mallow, toad-flax, and daisy. Many plants are useful in one locality, but known only as weeds in another. Cock's-foot (*Panicum crus-galli*) is a coarse grass, very troublesome in gardens in many Northern States, but in the South it is a valuable fodder plant. Besides these, there are plants of common cultivation which act as weeds, and are difficult to eradicate when it is

desired to grow other plants. Kentucky blue-grass, one of the most valuable forage plants known, is quite difficult to subdue, owing to its creeping root-stocks. On this account many farmers aim to exclude it from their farms, preferring such plants as clover and timothy, which, though inferior in some respects, are more easily subdued.

The following general hints on the destruction of weeds may be found of use. Whether it be profitable to attempt the complete extermination of weeds will depend on the price of land and labor, the kind of crops to be grown, &c. There can be little doubt, however, that the more troublesome perennial and biennial weeds can usually be eradicated altogether with profit, especially where they are not yet abundant:

HINTS ON KILLING WEEDS.

1. Plants cannot live indefinitely deprived of their leaves. Hence preventing their appearance above the surface will kill them sooner or later.
2. Plants have greater need for their leaves, and can be more easily killed in the growing season than when partially dormant.
3. Cultivation in a dry time is most injurious to weeds and beneficial to crops.
4. Avoid the introduction of weeds in manure or litter or from weedy surroundings. Some gardeners use no stable manure on grounds they desire to keep especially clean, relying on commercial fertilizers and the plowing under of green crops.
5. After a summer crop has ripened, instead of allowing the land to grow up to weeds it is often well to sow rye or some other crop to cover the ground and keep them down.
6. Give every part of the farm clean cultivation every few years either with a hoed crop or, if necessary, with a fallow.
7. It is often stated that cutting weeds while in flower will kill them. This is only reliable with biennials, and with them only when done so late that much of the seed will grow.
8. If the ground is kept well occupied with other crops weeds will give much less trouble. Keep meadows and roadsides well seeded and plow-land cultivated, except when shaded by crops.

Cnicus arvensis (canada thistle).

This thistle grows usually to the height of 2 or 3 feet, the stems very leafy and much branched, with the flower-heads gathered into small clusters at the end of the branches. The stem and branches are not winged by decurrent leaves, as they are in many other species. The leaves are comparatively small, those of the stem being mostly 3 to 6 inches long, about half an inch wide in the main part, with three or four prominent lobes on each side, and armed on the edges with an abundance of sharp, rather stiff, prickles, which are 1 or 2 lines long. The heads of the flowers are mostly less than an inch high, with a close involucre, the small scales mostly without prickly points. The flower-heads are mainly diœcious; that is, those of one plant are male only, while those of other plants are female only. The plant has creeping root-stocks, which spread deep beneath the surface and send up new stems, thus multiplying the plant. Although this plant is called Canada thistle, it is really a native of Europe, and has been intro-

duced into this country, probably first into Canada and from thence into the United States.

The Canada thistle nearly or quite fails to seed in many localities, spreading chiefly by the running root-stocks, so that it is not very rapidly disseminated. The failure to seed is doubtless mainly due to its diœcious character, as, if completely so, no seed would be formed where a patch originated from a single plant. It is not yet troublesome to any extent beyond the Eastern and Middle States. It prefers a heavy soil, but on such land is most easily killed. In pastures, or wherever the land is compact, if only a few plants appear they may often be killed by pulling them up a few times. Larger patches should be plowed deeply about once a week in the growing season, or each time before any plants appear above the surface. After each plowing rolling is advantageous, especially on sandy soil. There are numerous instances where fields of this weed have been completely killed in a single season in time to sow winter wheat. Cases have been reported of Canada thistles being killed by a single cutting at a certain period of growth. In some of these instances at least the plant has proved to be some other thistle. If the characters above given are borne in mind, especially the fact of the creeping root-stocks and of its growing on dry land, there will be little danger of this mistake.

Plate VI, Fig. 1, a portion of the stem, leaves, and flower-heads; Fig. 2, a portion of the running root-stock; Fig. 3, a single flower, with the seed and pappus.

Arctium Lappa (burdock).

A well-known biennial plant of the natural order *Compositæ*, which, like many of our common weeds, has been introduced from Europe. It has a thick branching stem, 3 to 5 feet high, with roundish heart-shaped leaves 3 inches to a foot or more long, the lowest on long stout stalks, the upper ones nearly sessile, the margins undulate and sometimes erosely toothed. The flower-heads are roundish, about an inch thick, mostly in small clusters at the ends of the branches. The scales of the involucre are extended into hooked points, which adhere to the clothing or to the hair or wool of animals. Within the involucre are a number of slender purplish flowers, each containing anthers and styles of the kind peculiar to this order, and at the base of each flower is the seed, surmounted with a number of slender bristles.

There are several varieties of this species, differing in the size of the heads and in other points, which varieties are by some called "species." It gives but little trouble in cultivated land, being found in waste places about buildings and fences, and occasionally in meadows where the seeding is thin. It prefers strong soil, and its presence is considered a sign of good land. Though not a serious weed in cultivated crops, its unsightliness and the annoyance of its burs in the wool and hair of animals make it desirable to try to exterminate it, especially as it is one of the easiest weeds to get rid of. One of the best times to destroy it is in the fall when the leaves are conspicuous and time is less pressing. It is killed any time if cut below the crown. It may also be killed by being mowed when the seed has fully formed, and the tops burned. If cut while in flower, as sometimes recommended, a second crop of seed will generally be produced.

Burdock has some reputation in medicine as a blood purifier and for rheumatism. Its value is probably slight. It is known in England as hare-burs or hurrburr, and the young shoots, after being stripped of

their rind, are occasionally used as a substitute for asparagus. In Japan it is cultivated under the name of gobo, the root, growing to 3 or 4 inches in diameter and often 2 feet long, being used much as we use salsify.

Plate VII, Fig. 1, a branch of the small variety; Fig. 2, a single flower magnified; Fig. 3, a portion of the large-headed variety—*major*.

Xanthium Canadense (clot-bur, cockle-bur).

A coarse branching annual plant of the order *Compositæ*, usually 1 to 3 feet high, with alternate, rough leaves from 3 to 6 inches long and about as wide, somewhat lobed and coarsely toothed, strongly three ribbed, somewhat heart-shaped at the base, and on long stalks. The flower-heads are in small axillary and terminal clusters of 2 kinds, male and female, the male heads on a short spike at the summit and the female in clusters of 2 or 3 at the base of the male spike. The male or staminate flowers are in roundish heads, with a thin scaly involucre. After shedding the pollen these heads soon drop off and disappear, and the female heads enlarge, and become thick, hard, oblong burs about an inch long, beset with stiff hooked prickles. At the apex of the bur there are two hard and sharp or hooked beaks, and within are two cells, each containing a single seed. Those who are accustomed to look at the aster and the sunflower as representatives of the order *Compositæ*, will not at first recognize this plant as a member of that family because of the separation of the male and female flowers, but a close examination will reveal its true position.

This plant is most abundant on low pasture and stubble land and along streams, though often growing rankly in waste places on upland. It is seldom a troublesome weed in crops, but its burs are a great annoyance in the fleeces of sheep. Seeding to clover and meadow grass and mowing several times the first season is recommended for its destruction.

We have figured this species (*X. Canadense*), believing that it is the one which is troublesome in corn fields and roadsides in the Western States, where it is probably native, but perhaps introduced from the South through travel and commercial intercourse. The species which occurs in the Eastern States is probably *Xanthium strumarium*, which is supposed to be a native of Europe and India. It is smaller in size, with smaller burs, more slender and smoother prickles.

Dr. Gattinger, of Nashville, Tenn., states that some twenty-two years ago he fed his horse quite a quantity of the *Xanthium Canadense* in its flowering season. It possesses an aromatic smell, and his horse liked it. It did not have any noxious effects upon him, although he has since heard a farmer say that it was poisonous to stock, which, however, he does not believe.

Plate VIII, Fig. 1, a branch, showing the spikes of male flower-heads, with the female clusters below; Fig. 2, three mature burs.

Ambrosia artemisiæfolia (rag-weed, bitter-weed, hog-weed, Roman wormwood).

A common annual weed of the natural order *Compositæ*, generally 2 to 3 feet high, rather slender, and much branched. The leaves are from 1 to 4 inches long, mostly alternate and thinnish, pinnatifid, or cut into deep narrow lobes, which are again lobed or toothed. The ends of the branches bear the flowers, which are of 2 kinds male and female. The male flowers are in small heads of 5 to 8 to

gether, inclosed by a 5-toothed green involucre. These heads are arranged in a slender, spikelike raceme 2 to 3 inches long, each one nodding on the very short recurved pedicel. At the base of the raceme are a few female flowers, which are erect, some of which develop into small hard nutlets or fruits. The flowering spikes are quite variable, sometimes being nearly all male, and sometimes mostly or entirely female. It seems to be an American weed, native of the warmer parts of the continent, but by cultivation introduced and spread over the United States and Canada.

It is very common in wheat-stubble and along roadsides. In Ohio it was reported to the State experiment station in 1883 by the greatest number of correspondents as the most troublesome weed in corn. It thrives on all soils, and can be eradicated only by the most careful cultivation. It is kept down in well-seeded meadows, but some of the plants persist, and produce seed when but a few inches high. Sheep are a valuable stock to keep on land infested with this and other weeds.

Plate IX, a branch with the flowering spikes; Fig. 1, a single male head; Fig. 2, a fertile nutlet.

Chrysanthemum leucanthemum (white daisy, ox-eye daisy, white-weed).

A perennial plant, 1 to 2 feet high, simple or with few branches, often several stems from one root. The stem is rather sparsely clothed with narrow, coarsely-toothed or gashed, obovate or spatulate leaves, the upper ones sessile with a clasping fringed base, the lower ones more or less petioled. The main stem and the few long branches are each terminated with a single head of flowers, which, when expanded, is an inch to an inch and a half in diameter. There is an external set of thinnish scales, which is called the involucre; within this are the florets, or flowers, of 2 kinds—an outside row of showy, white flat florets called "the ray," and a central mass of short tubular yellow florets, which constitute the "disk."

Both the ray and disk florets are fertile; that is, provided with an achenium or seed at the base. If the small disk florets are carefully examined they will each be found to contain 5 stamens united by the anthers around the central style. In the ray florets the stamens are absent. The plant is a native of Europe, but has become widely spread over all the eastern part of this continent.

The daisy is most troublesome in meadows and pastures. Though long known in this country, it is still spreading westward into new localities. In some cases it has escaped as a weed from flower gardens; in others it is introduced in grass or cloverseed or hay. It has been introduced in some places as a grazing plant for sheep, though the close grazing of the sheep will exterminate it. Where the plant is abundant it has been utilized to restore worn-out land too poor to grow clover. For this purpose it is sown at the rate of one-fourth bushel per acre. It is too much of a weed, however, to be introduced into a new locality for any purpose. If the land is brought to the proper state of fertility grass and clover will keep the daisies down, so that the few which remain may be readily exterminated. (Plate X.)

Abutilon avicennæ (Indian mallow, velvet-leaf).

A coarse annual plant of the order *Malvaceæ*. The stem is branching and grows to the height of 4 or 5 feet. The stem, branches, and leaves are covered with short soft hairs; hence the name of velvet-

leaf. The leaves are roundish-ovate, 3 to 6 or more inches long, and rather long-pointed, heart-shaped at the base, the margins with fine blunt teeth, and with a stalk longer than the leaf. There are about 5 principal nerves diverging from the base.

From the axil or angle of each leaf-stalk is produced a flower-stalk, which develops 1 or 2 flowers or is sometimes extended into a branching raceme, with 3 to 5 flowers. The flowers consist of an outer calyx, cleft into 5 lobes or teeth, the corolla consisting of 5 obovate orange yellow petals, and a column of numerous stamens united into a tube, which closely surrounds the 12 to 15 styles. The expanded flower is half to three-fourths of an inch in diameter. After the fall of the corolla the ovaries develop into a crowded mass of dry pods or capsules, each one having 2 short stiff points or teeth, which spread or radiate upward and outward. The base of this mass of carpels is surrounded by the persistent calyx. The calyx and capsules are soft, hairy, or pubescent.

In some parts of the country this plant is called stamp-weed, because the pods are used to ornament or stamp butter.

This plant, originally from India, has spread quite extensively in Europe and Asia, and also in the United States, where in some localities it has become a serious weed in rich cultivated grounds. It was long sold as an ornamental plant; but few, if any, seedsmen now offer it. It possesses a strong fiber, which some have attempted to utilize for manufacturing purposes. (See Report 1879, p. 508.) Being an annual, and easily recognized, and generally confined as yet to limited localities, it would seem to be more easy to get rid of than many of our weeds. (Plate XI.)

Solanum Caroliniense (horse-nettle).

A low, perennial plant, with deep, running roots, belonging to the order *Solanaceæ*, the same that contains the potato, tomato, &c. The stems are 1 to 2 feet high, rather straggling, branching, and half shrubby at the base. The stems and the midnerve of the lower side of the leaves are more or less thickly armed with short, sharp, stout, yellowish prickles. The stem and leaves are also covered with minute star-shaped hairs of from 4 to 8 points. The leaves are large for the size of the plant, 2 to 4 inches long, short-stalked, oblong in outline, sometimes only coarsely and irregularly toothed, sometimes with 3 to 5 deep lobes on each side. The flowers are in racemes, mostly from the axils of the upper leaves. There are from 3 to 10 flowers on each raceme, on rather short pedicels. They are an inch or less in diameter when expanded, having a 5-parted calyx and a 5-lobed bluish or whitish, spreading corolla. The flowers are succeeded by round berries, half to three-fourths of an inch in diameter, when mature of a yellowish color, and filled with pulp and numerous small seeds. The pedicels of the berries are reflexed, and the berries remain upon the plant into the winter. Common in the Southern and Western States, and becoming too frequent in the North. Darlington says:

> This is an exceedingly pernicious weed, and so tenacious of life that it is almost impossible to get rid of it when once fully introduced. It grows in patches so thickly as to deter stock from feeding among it and even to monopolize the soil, while its roots gradually extend around and to a great depth.

It seems to prefer sandy soil, at least in the North, where it is sometimes called sand-brier. As it is perennial, and spreads by the root, only the most thorough treatment will eradicate it.

Plate XII, Fig. 1, a branch; Fig. 2, a raceme of mature berries.

Echium vulgare (blue-weed, blue-thistle, bugloss).

A biennial plant, of the order *Borraginaceæ.*

The stem is from 2 to 3 feet high, rough, hairy, and leafy. The leaves vary from lanceolate to linear, the lower ones 5 to 8 inches long, becoming shorter above, the uppermost bractlike and shorter than the flowering racemes. Like the stem, they are roughened with stiff whitish hairs, which have a stinging quality. The upper part of the stem, sometimes for more than half its length, bears numerous short, axillary spikes or racemes of flowers. These racemes are 1 to 2 inches long, and are coiled backward in bud, but straighten out as they expand. The flowers are rather crowded, and consist of a 5-lobed or cleft calyx, and a somewhat bell-shaped corolla about an inch long, which is purplish at first but changing to a light blue. When in full flower the plant has a handsome appearance. The nutlets, of which there are about 4 in each flower, are small, roundish, and rough, with a peculiar appearance, which has been likened to a viper's head. This plant is a native of Europe and Asia, but has become extensively naturalized along roadsides, in waste grounds and fields, principally in the Middle Atlantic States. (Plate XIII.)

Rumex acetosella, (sheep sorrel, field sorrel).

This small plant belongs to the order *Polygonaceæ,* or the family which contains the wild buckwheats and the docks. It multiplies rapidly by underground runners or roots. The stems are seldom more than 15 or 16 inches high, and are slender, erect, somewhat angular, and furrowed. The leaves are rather distant on the stem; the root and lower stem-leaves are on long and slender petioles, the upper ones becoming short-stalked or sessile. They have the peculiar form which is called *hastate,* that is, arrow-shaped, with the lobes spreading outward, or at right angles to the main part. Sometimes in the upper leaves the lobes are wanting.

The flowers are in racemes, at small distances apart, and in whorls of 3 to 6, nodding on the very short pedicels. The plant is of the kind called diœcious; that is, all the flowers of one plant are of one sex, either male or female. The flowers are very small, and in the male plants consist of the calyx of 6 sepals, 3 inner and 3 outer ones, and 6 stamens. In the female plants (and these are said to be larger than the male plants) the calyx is the same, but in place of the stamens, the small ovary, with its feathery stigmas, is seen, the ovary finally enlarging to form the 3-angled fruit. This sorrel is a native of Europe, but has become extensively naturalized in our country. It is often stated that the presence of sorrel is an indication of an unusual amount of acid in the soil, and that an application of lime or other alkali eradicates the sorrel by correcting the acidity. Such is not the case. Sorrel is generally most abundant on poor, light land, where little else will grow. An application of lime or other fertilizer enables other plants to grow and crowd out the sorrel.

Plate XIV, Fig. 1, a male flower magnified; Fig. 2, a female flower magnified.

Lychnis Githago (corn-cockle, or cockle).

A rather showy annual plant, belonging to the same family as the pink and sweet-william. It is a native of Europe, from whence it has been introduced with grain, and is now too commonly found in fields of wheat and rye.

The plant is from 2 to 4 feet high, sparingly branched above. The leaves are narrowly lanceolate, 3 to 5 inches long, less than half an inch wide, gradually tapering to a point, entire, thick, and, like the branches and calyx, covered with fine soft hairs. They are in single pairs at the base of each branch and opposite each other. The branches are slender, naked, and terminated with single flowers, which are 2 to 2½ inches long when expanded.

The calyx is 10-ribbed, and divided into 5 linear lobes, similar to the leaves, and longer than the corolla, which consists of 5 obcordate petals of a reddish-purple color, and about 1½ inches long. There are 10 stamens and 5 styles. The ovary develops into a roundish-oblong pod, filled with numerous dark-purple seeds, which under a lens are beautifully ribbed and roughened.

In regard to the comparative injury to wheat by cockle and chess a grain-dealer of Michigan writes:

In this State there is much more chess in wheat than cockle, but it is screened out easily, whereas cockle is very difficult to screen out, as it is as heavy and has nearly as large a berry as wheat. The chess is of no value, while the presence of cockle makes the flour of low grade.

A grain-dealer at Duluth, Minn., writes, December 30, 1886, concerning cockle:

Its effect on the grade of wheat as inspected here is serious. We had one car, which contained No. 1 hard wheat (our highest grade here), reduced to rejected (which is next to the lowest grade) solely on account of cockle. That would make a reduction in price of at least 15 cents per bushel.

A Minneapolis (Minn.) miller writes:

Cockle runs from 1 to 5 pounds to the bushel, 5 pounds being an extreme percentage. It is abolutely impossible to clean all the cockle out of the wheat, as it is so near the weight of the berry. Chess is found in winter-wheat sections, and can be all cleaned out of the wheat, as it is light, and can be handled to much better advantage than the cockle.

Sow a portion, at least, of the crop with perfectly clean seed on land where no grain grew the year before. Use this for the next year's seeding. In a few years the crop will be free from cockle. If, when clean seed is obtained, it is offered to surrounding growers, the area free from this weed may be extended, so as to lessen the liability of its being again introduced.

Plate XV, Fig. 2, a section through the ovary; Fig. 3, a seed magnified.

Chenopodium album (pig-weed, lamb's quarters).

This very common weed is of variable size, sometimes in good soil growing 5 or 6 feet high, in other circumstances reaching only 1 or 2 feet. The stem is rather stout and angular, and much branched. The leaves are on rather long and slender petioles, and vary from 1 to 3 inches in length, of an oblong or ovate form, the larger ones coarsely and irregularly toothed, the smaller ones narrow and mostly entire. The flowers are in small roundish clusters, at short distances apart, on slender spikes or racemes, which terminate the branches. The flower clusters are covered with a whitish mealy powder, and in many cases this mealiness extends also to the leaves. The individual flowers are very small, consisting of a five-cleft calyx, 5 stamens, and an ovary with 2 styles. The flower is destitute of a corolla. The mature ovary or seed is round in outline, but much flattened and lens-shaped, smooth, shining, and black, inclosed in a thin green

pericarp or cover. These parts require to be magnified to be distinctly seen.

This plant, as well as a number of others of the same family, is a native of Europe, but is extensively naturalized, and is found in waste places and cultivated ground. The young plants are sometimes used as a pot-herb.

The variety *viride*, by some considered a distinct species, has also been introduced, and is becoming in some localities even more abundant than the other. It is of a deeper green, has narrower leaves, and blooms earlier. (Plate XVI.)

Ranunculus acris (buttercup, tall crowfoot).

A perennial herb of the order *Ranunculaceæ*, a native of Europe but extensively naturalized in New England and New York in pastures and meadows. The roots are fibrous, the stem is about 2 feet high, and branching near the summit. The leaves are mostly from the base, and on long stems, which are generally clothed with soft hairs. These leaves are roundish in outline, but divided into about three or five principal segments, and each segment is again parted into about three divisions, which are again cut into coarse teeth or lobes. The stem has but few leaves, and those more deeply gashed, with the uppermost reduced to a few linear segments. The flowers are at the ends of the long naked branches, either singly or 2 or 3 near together. They are about three-fourths of an inch in diameter and of a bright yellow color. The calyx consists of 5 green sepals, which are shorter than the petals and spread out horizontally. The outer organs soon fall off, and the ovaries mature into a roundish head of small, hard, flattened, and pointed carpels.

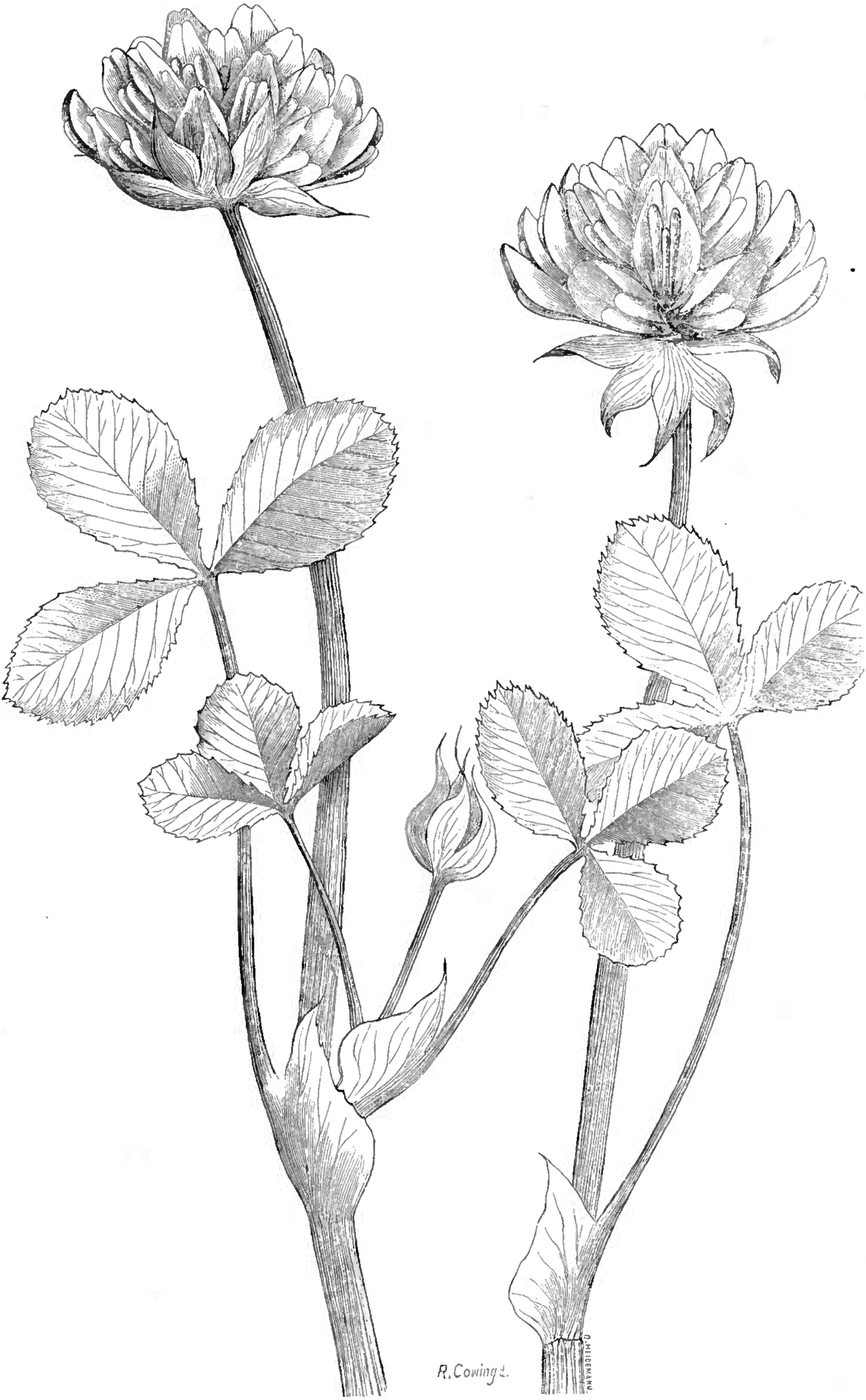
It is not uncommon in the New England States and in New York to see large fields of pasture-land completely taken possession of by this buttercup or crow-foot. On account of the acrid juice which it contains it is always rejected by cattle in the field, but as the acridity is dissipated by drying, the leaves are eaten when present in hay, but the long coarse stems are so much waste matter. (Plate XVII.)

Ranunculus bulbosus (bulbous-rooted buttercup).

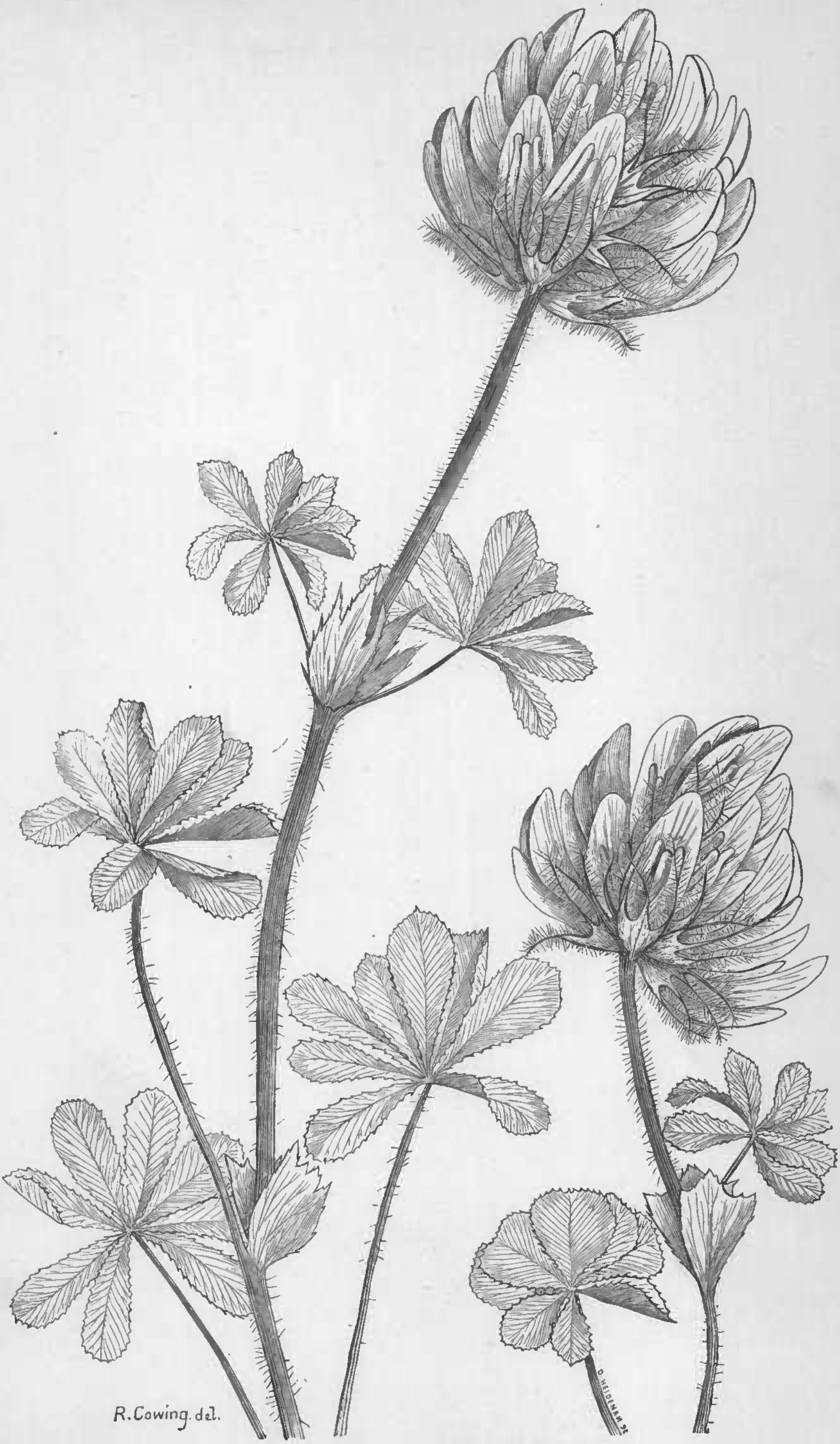
A small species of buttercup, with a roundish bulbous root, also introduced from Europe and naturalized in some places, particularly in Pennsylvania and Virginia, to such an extent as to be quite a pest in meadows and pastures. The segments of the leaves are about three, not so close together as in the *R. acris*, and generally with fewer lobes. The flowers are of about the same size and color as the preceding, but the sepals or parts of the calyx are reflexed. (Plate XVIII.)

Barbarea vulgaris and *Barbarea præcox* (winter-cress, scurvy-grass).

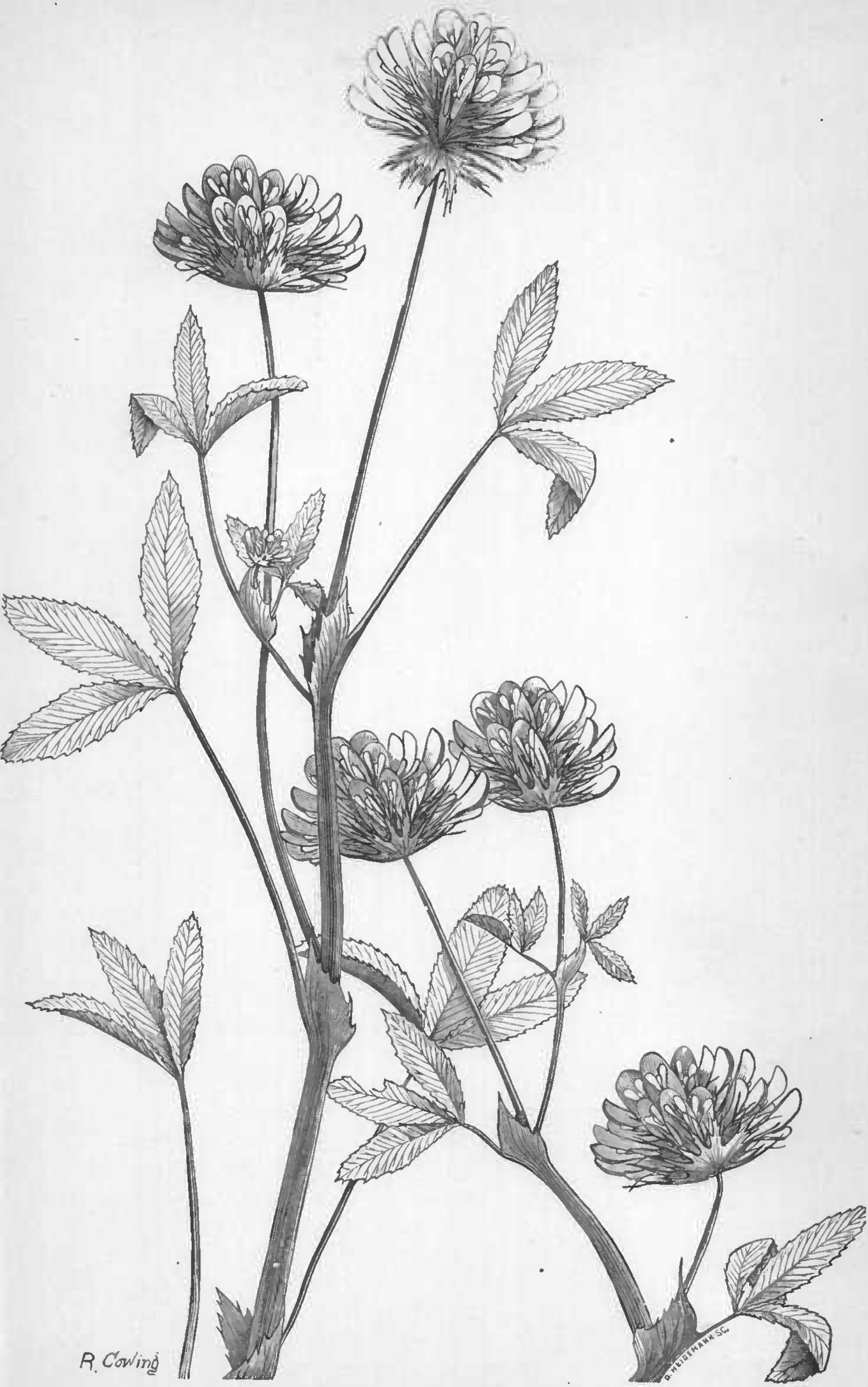
A biennial plant of the natural order *Cruciferæ*, related to the mustard, turnip, cress, and cabbage. It grows to the height of about 2 feet. The stem is disposed to branch at the upper part. It produces numerous yellow flowers in rather close, short racemes, which as they grow older are elongated and covered with somewhat four-sided, narrow pods, about an inch in length. There are two species, differing principally in the leaves, which in *B. vulgaris* are shorter, with a large roundish extremity and sometimes a few short lobes be



TRIFOLIUM FUCATUM.



TRIFOLIUM MEGACEPHALUM.



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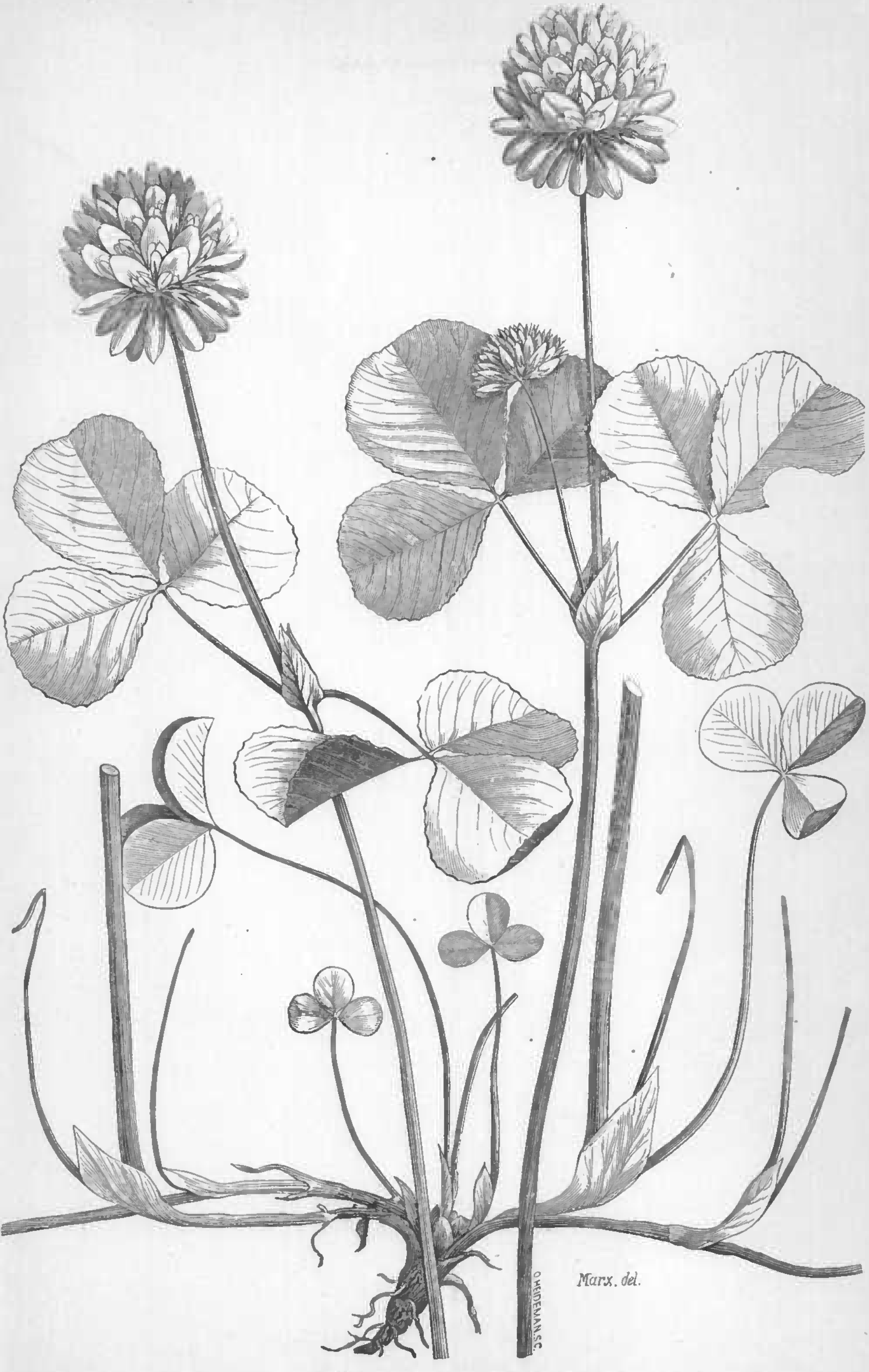
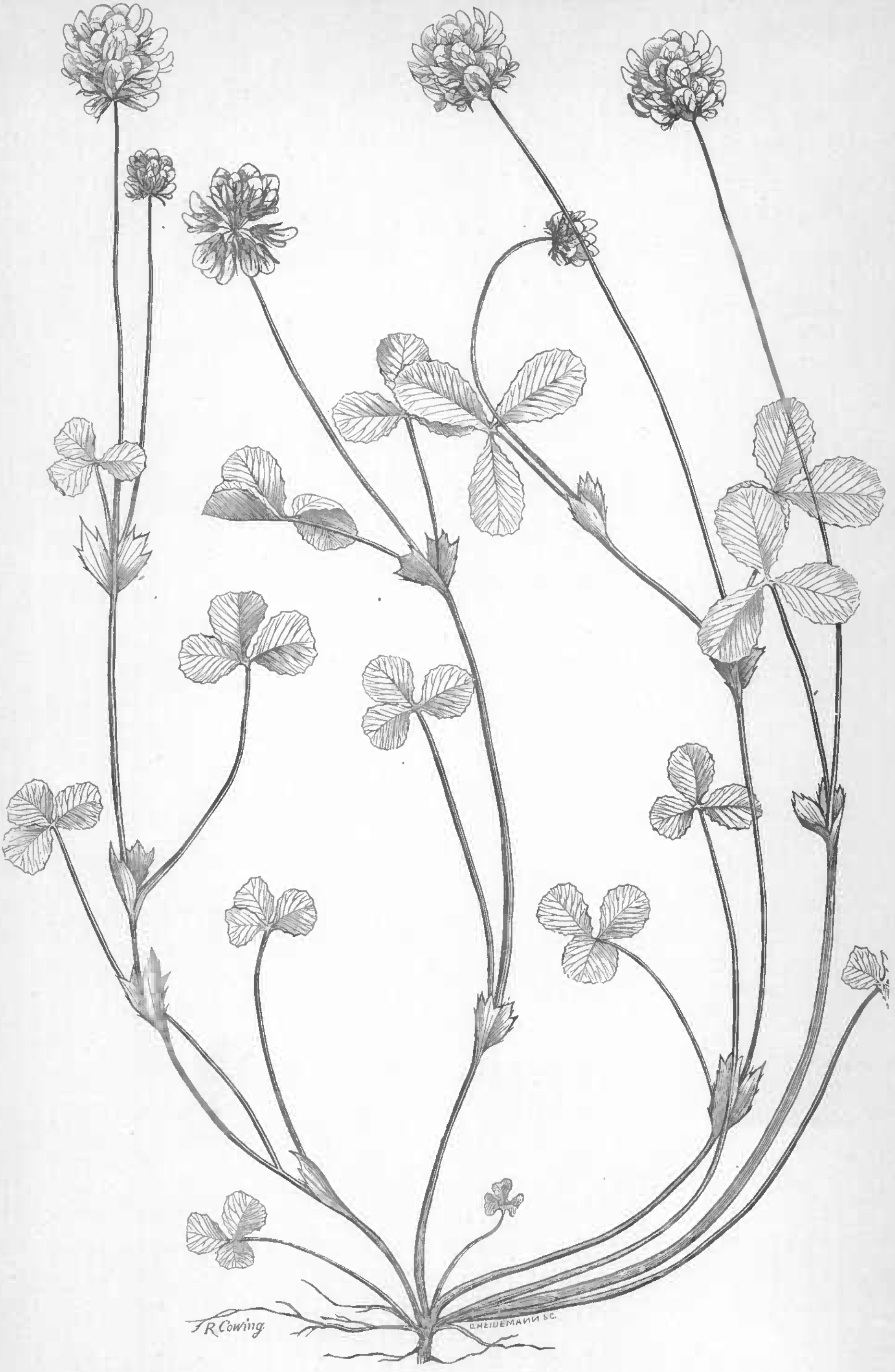


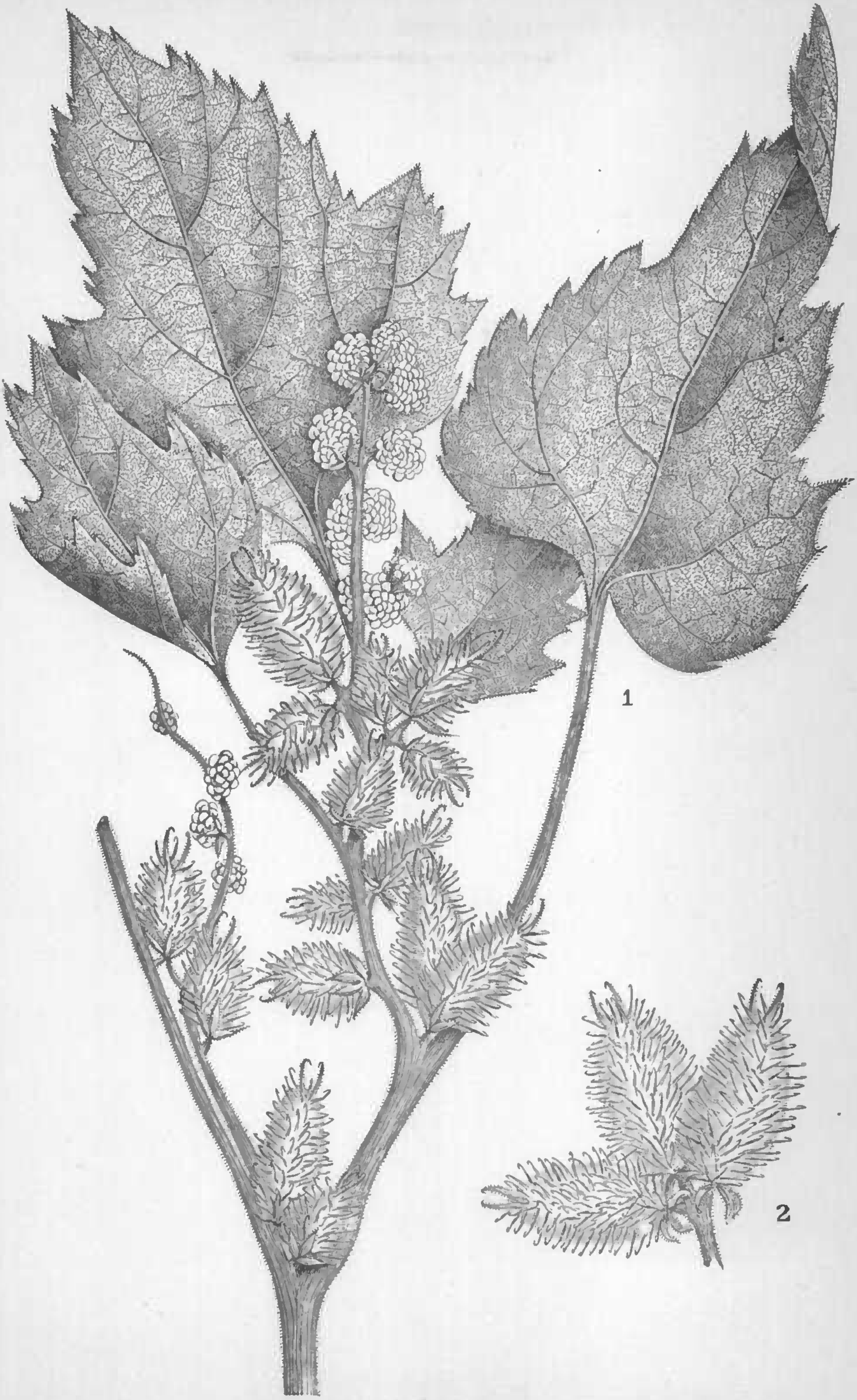
TRIFOLIUM STOLONIFERUM.



Trifolium Carolinianum.

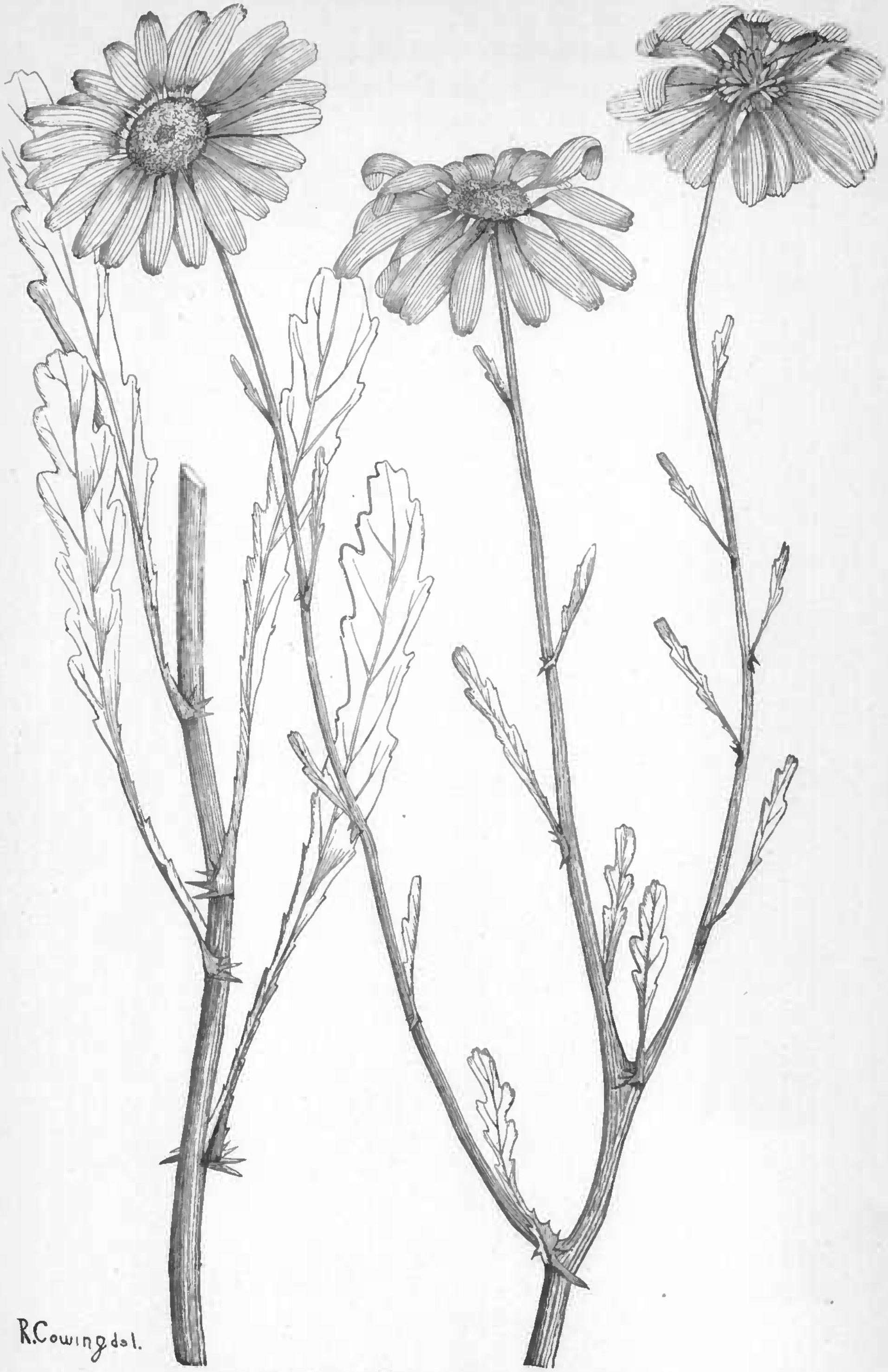
CNICUS ARVENSIS (CANADA THISTLE).

ARCTIUM LAPPA (BURDOCK).

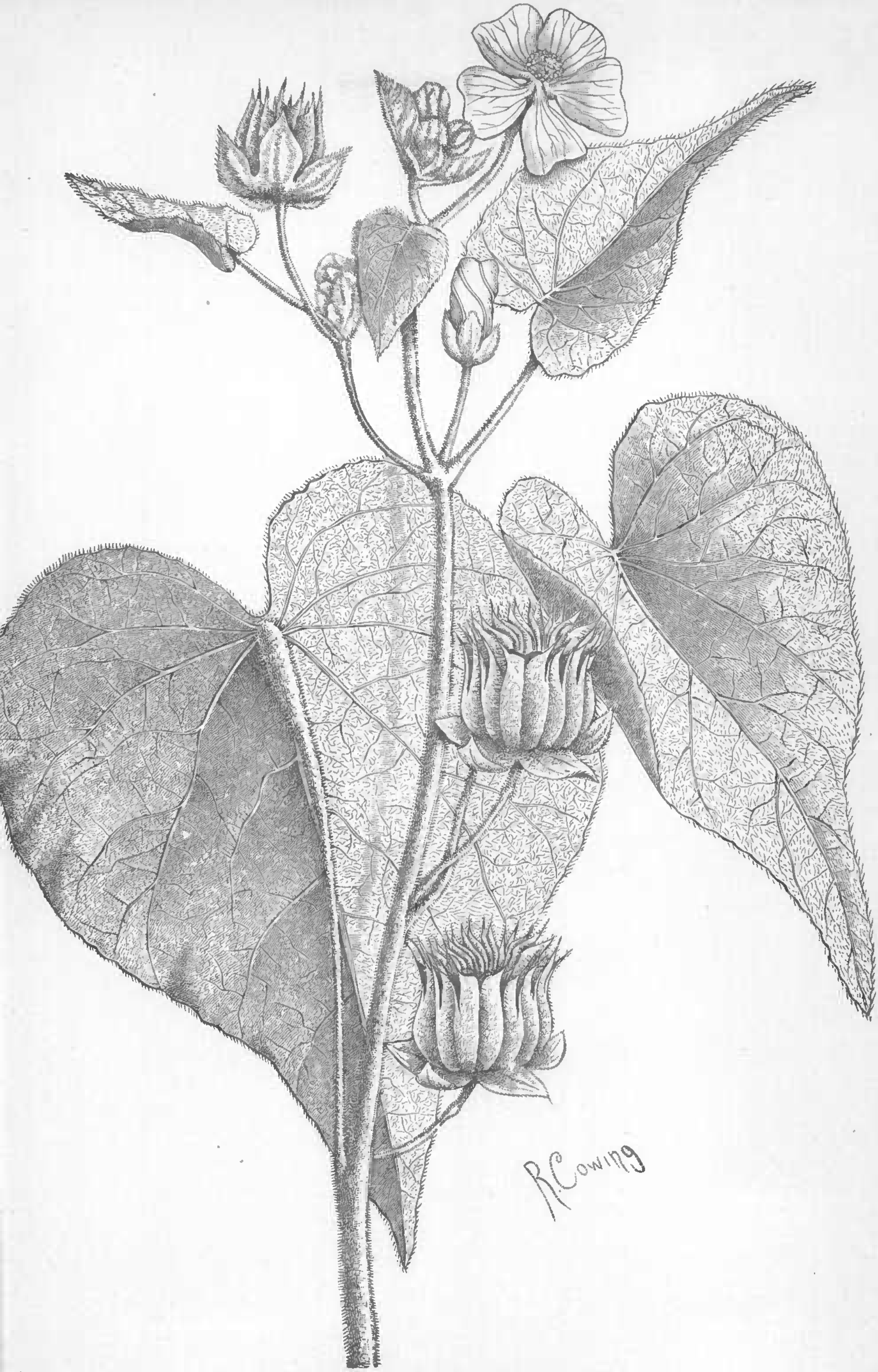


XANTHIUM CANADENSE (CLOT-BUR).

AMBROSIA ARTEMISIÆFOLIA (ROMAN WORMWOOD).



CHRYSANTHEMUM LEUCANTHEMUM (WHITE DAISY).



ABUTILON AVICENNÆ (VELVET-LEAF).

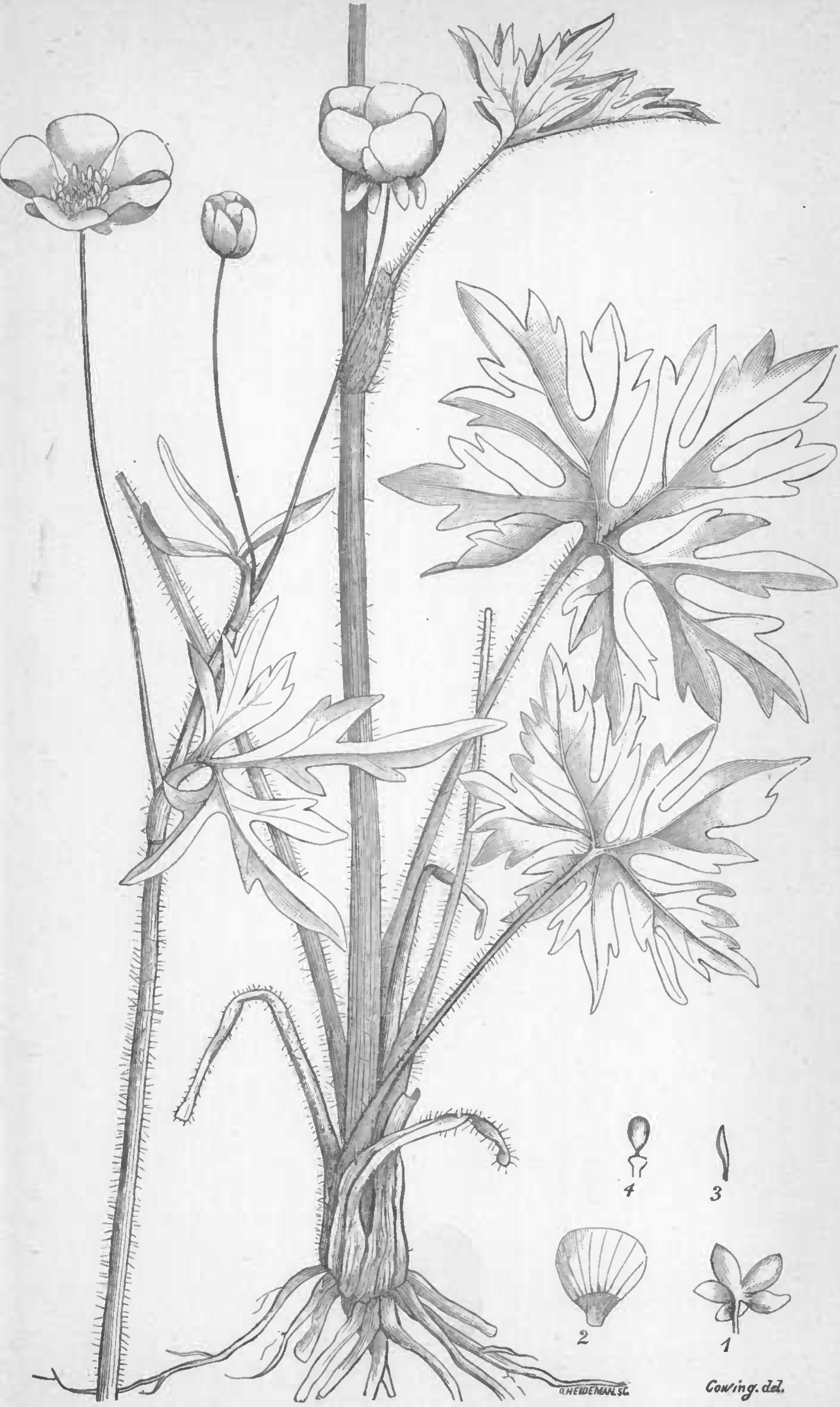
SOLANUM CAROLINENSE (HORSE-NETTLE).

ECHIUM VULGARE (BLUE THISTLE).

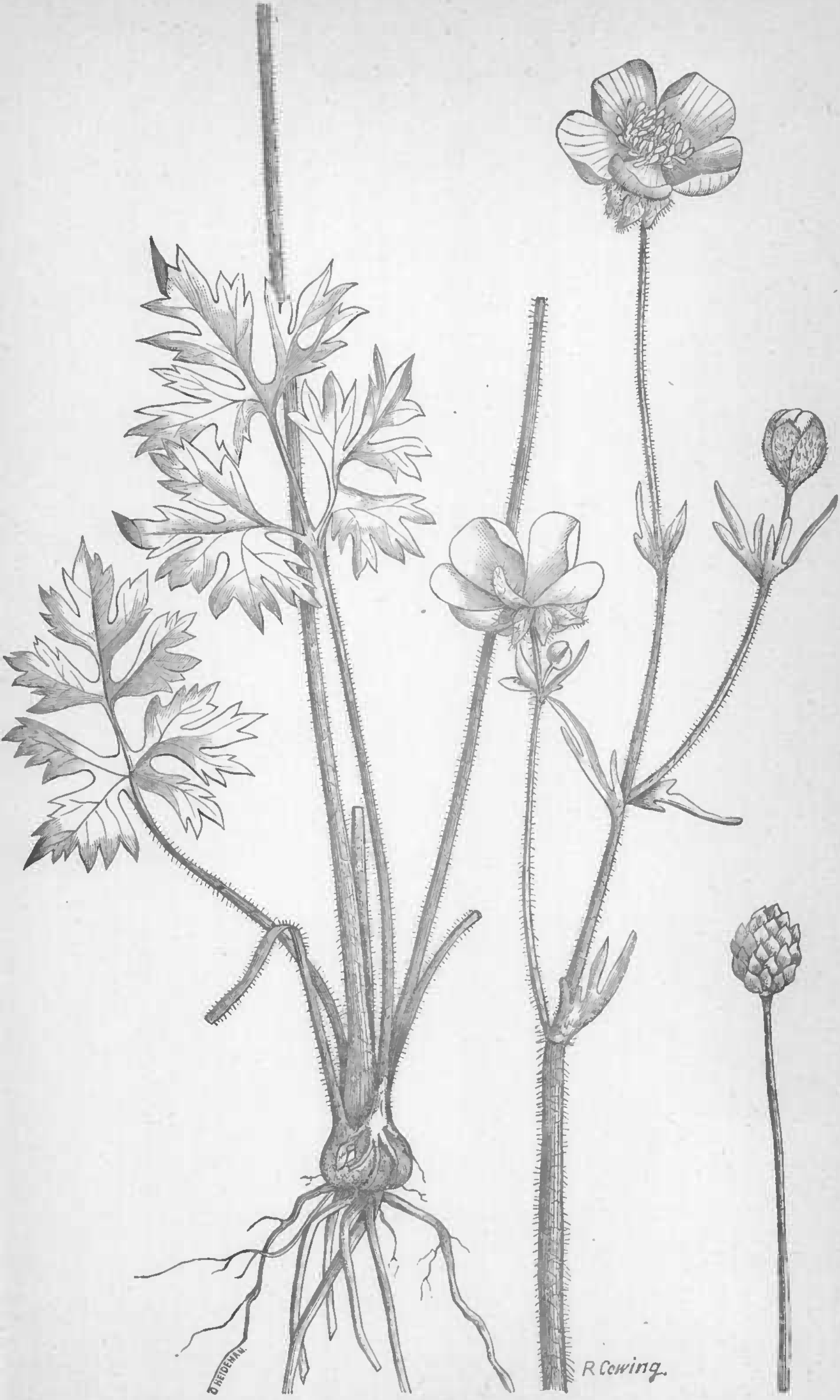
RUMEX ACETOSELLA (RED SORREL).

LYCHNIS GITHAGO (CORN COCKLE).

CHENOPODIUM ALBUM (PIG-WEED).



RANUNCULUS ACRIS (TALL CROWFOOT).



RANUNCULUS BULBOSUS (BUTTERCUP).

BARBAREA VULGARIS (WINTER CRESS).

CHELIDONIUM MAJUS (CELANDINE).

CAPSELLA BURA-PASTORIS (SHEPHERD'S-PURSE).

low; in *B. præcox* the leaves are longer and pinnatifid, with irregular lobes, decreasing in size from the apex toward the base.

In the vicinity of New York, Philadelphia, Baltimore, &c., this plant is considerably cultivated as an early salad, and has escaped from cultivation to such an extent as to become very troublesome in cultivated fields. As found in these places it is probably introduced from Europe, but in the neighborhood of the great lakes, in Canada, and northward it is thought to be a native plant. (Plate XIX.)

Chelidonium majus (celandine).

A plant of the poppy family (*Papaveraceæ*). It is herbaceous and perennial, growing 1½ to 2 feet high, with a brittle, watery stem, which when broken emits a yellowish, disagreeable-smelling juice, which is bitter and acrid. The stem is somewhat branching, with large pinnatifid leaves. Those from the root are on long stalks, those on the stem are short-stalked or the upper ones sessile. They are usually 3 or 4 inches long and nearly as broad, divided into about five principal segments, which are again subdivided into a few lobes and coarse teeth. The flowers are in small clusters of 3 to 8 at the extremity of the branches, each one on a short stalk or pedicel. They are less than an inch in diameter when expanded, and of a bright yellow color. The calyx consists of 2 greenish sepals, which fall off when the flower expands. The corolla is composed of 4 oblong petals, within which are an indefinite number (usually from 16 to 20) of stamens, and centrally the ovary, which enlarges into a slender, smooth, two-valved, many-seeded pod, about an inch in length.

This plant is rather common about dwellings in the Eastern States, and, although classed as a weed, it is one which interferes principally with garden culture. Like many other common weeds, it is introduced from Europe. (Plate XX.)

Capsella bursa-pastoris (shepherd's-purse).

One of the commonest garden and roadside weeds. It is an upright annual plant of variable size, sometimes fruiting when 2 or 3 inches high, and sometimes attaining a height of 18 inches or more. The leaves are mostly near the lower part of the plant, the upper ones becoming small, narrow, and somewhat arrow-shaped, while the lower ones are sometimes 5 or 6 inches long, pinnatifid, and toothed like those of the dandelion. The flowers are very small, and at first somewhat crowded near the end of the branches, but in age becoming much separated, and forming a long, leafless raceme. The flowers have the same general structure as those of pepper-grass and radish, and the plant belongs to the same natural order, *Cruciferæ*. The pods are on slender pedicels, which are half to three-fourths of an inch long. They are about one-fourth of an inch long, of a peculiar form, flat, broad at the top, and notched at the apex, then narrowed to the base, presenting somewhat the appearance of a purse, from which appearance comes the common name of shepherd's-purse. The pods consist of two lobes or pouches, fixed on opposite sides of a flat thin partition, to which the seeds are attached. Although this weed is very common and abundant, it can generally be easily destroyed by careful culture. (Plate XXI.)

GEORGE VASEY,
Botanist.

HON. NORMAN J. COLMAN,
Commissioner.

REPORT OF THE MYCOLOGICAL SECTION.

SIR: Appointed by you, upon the 1st of last July, to take charge of the section of the Botanical Division, devoted to the "investigation of the diseases of fruits and fruit trees, grains and other useful plants, caused by fungi," I have the honor to make the following report:

It will be seen from the very nature of the work of this section that it is too early to expect the attainment of any definite results from original investigations, and whatever subjects are now discussed can only be looked upon as preliminary to more complete and ex haustive studies.

The fungi which infest our cultivated plants, and not infrequently cause their total destruction, vie with the insect tribes in numbers as well as in the extent of the losses they occasion, and the transformations they undergo in their development are equally complex and often even more difficult to follow. They are, for the most part, so small, and the metamorphoses they undergo so obscure, as to call for the greatest amount of patience and the closest study in order to obtain any satisfactory knowledge of their natural history, and in spite of all our efforts there will frequently remain many points which must be left to conjecture.

That these fungi, which make themselves manifest in the plant diseases familiarly known as "rust," "smut," "mildew," "blight," &c., are true vegetable parasites; that they are governed by the same laws which control all living organisms; and that they are propagated by specially developed reproductive bodies called spores, are fundamental truths to be kept constantly in mind in studying this subject. There is no such thing as spontaneous generation among these parasites, and whenever a fungus appears it is as certain that it was preceded by a spore as that the oak came from an acorn, and, further, that the germination of the acorn and spore was only effected by surroundings and conditions favorable to its accomplishment. We have a pretty fair knowledge of what these conditions are in the one case, but simply because those in the other are not so well understood we must not deny their existence.

In order to make an intelligent use of remedies for checking or preventing the ravages occasioned by injurious fungi, which is the primary and ultimate object of the work of this section, it is manifestly essential to gain a complete knowledge of their nature and habits. To accomplish this will require much time and research, but in no other way can we hope to attain results of positive value. Those species which grow within the tissues of the plants they infest demand a different treatment from those which live wholly upon the surface. Species which live only for a time upon some useful plant, passing the remainder of their existence upon some worthless weed or some plant in decay, can be managed differently from those that infest only a single host. A complete knowledge of the life history of these parasites cannot fail to bring to light some weak point in their development which may be taken advantage of in seeking their destruction.

No systematic experiments have been attempted in this country to prove the general value and efficacy of the various fungicidal preparations which have been proposed from time to time by individual cultivators for certain plant diseases. The general impression prevails that sulphur is a universal panacea for all the ills, of a fungus origin, that plants are heir to, but the value of this substance is limited to a small group of these parasites, and here even its action is not always certain. There exist prejudices, however, in favor of the use of sulphur as a fungicide which operate against the introduction and use of other and more active remedies. There has been also a certain feeling of indifference on the part of farmers and fruit-growers relative to this subject, doubtless due to the greatness of our country and the variety of our resources, but more especially to the almost entire absence of information respecting the nature and habits of the fungi themselves. With increasing cost of production and greater competition the producer is feeling more and more keenly the losses which diminish his profits; he has come to realize fully the gravity of the ravages wrought by fungi, a fact well attested by the numerous letters received from agriculturists and fruit-growers throughout the country, earnestly asking information on this subject and the assistance that will enable them to prevent the depredations of these parasites.

The most important work of this section during the past season has been the preparation of a special report (Bulletin No. 2) of the Botanical Division, on the "Fungus Diseases of the Grape-Vine." In consideration of the importance of the subject treated in this report, together with the fact that the edition printed is already nearly exhausted, it has seemed advisable to present here an abstract of some of the leading topics discussed in it.

I.—The Downy Mildew.

Peronospora viticola, De By.

(Plate I.)

The Downy Mildew is common to both the wild and cultivated grapes of this country, and from the former it doubtless was conveyed to the latter in the earliest days of American grape culture.

In some respects it may be deemed a more serious enemy to viticulture than Black-rot, for by its action on the leaves it affects the nutrition of the vine, weakening the vitality of the latter and eventually destroying it. This action upon the leaves interferes with the development of woody tissue in the growing shoots and prevents the ripening of the fruit, and the wine produced will be inferior both in quantity and quality.

The Downy Mildew attacks all the green portions of the vine—the leaves, young shoots, and berries—and is a true parasite, closly allied to the fungus of the potato-rot. The fungus consists of a mycelium, which grows within the tender tissues of the vines attacked, and of the reproductive bodies or spores.

The mycelium.—The vegetative portion, or mycelium, of the fungus grows between the cells composing the tissues of the leaves, young grapes, and shoots, never through them, and the threads, or hyphæ, of which it is made up, branch most irregularly and vary greatly in diameter. These threads have no cross partitions, or septa, but are continuous throughout their whole length, and are filled with a col-

orless, granular, and somewhat oily substance. At frequent intervals on these threads, as they push their way between the cells, minute lateral projections are formed, that penetrate the walls of the adjacent cells of the host, from which they absorb the nourishment for the support of the parasite. These projections have received the name of "suckers," or haustoria. The contents of the perforated cells quickly turns brown, ultimately effecting the outward changes in the coloration of the leaf or other affected part.

Upon this mycelium, at different periods and in very unlike ways, two sorts of reproductive bodies, or spores, are formed; one kind produced externally on short filaments, and named conidia, the other developed by a special sexual process on the mycelium within the tissue of the host plant, and termed oöspores. The first are produced in great numbers throughout the summer, and serve for the immediate propagation of the fungus, effecting its rapid distribution; the second are formed later, and do not germinate until the following season. The former are often called "summer spores," in distinction from the latter, which have been named the "winter spores."

Summer spores.—The summer spores, or, as they are technically called, conidia, are borne upon the ultimate branches of slender filaments of the fungus, which issue through the natural openings, the breathing pores of the leaves. Four to five, or even more, of these filaments, called conidiophores, or conidia-bearers, issue from each pore, and through their abundance the fungus becomes visible to the naked eye; the downy white patches of mold, so conspicuous on the under surface of affected leaves, being wholly of this growth.

A few hours of a single night is all the time required for the development of the conidiophores and conidia, but the mycelium may exist within the tissues of the leaves or other affected parts a long time before this outward development takes place. The conidiophores only appear under certain favorable atmospheric conditions, and, as these conditions may only occur at intervals of considerable length, we are in the habit of assuming that a new infection takes place each time. That vines previously free from the mildew may become affected at any time during the summer there is no doubt, but the appearance of the mildew on the leaves may come from mycelium that arose from a much earlier infection.

The number of conidia that may be produced upon a single invaded vine has been estimated at from two to ten millions. Their great number, coupled with the fact that each one may produce a half a dozen or more new individuals, explains how it is that an entire vineyard may be "struck" with the mildew like the sudden falling of a cloud upon it.

In shape the conidia are generally ovoid, the smaller end being at the point of attachment, their longest diameter being from $\frac{6}{10000}$ to $\frac{9}{10000}$ of an inch. They are very thin-walled, and are filled with a colorless, nearly transparent, granular fluid. Their formation takes place with great rapidity, and when mature they are most easily detached from their supports.

One of these bodies, happening to fall upon a grape-leaf where there is moisture condensed in the form of drops of rain or dew, will germinate within a couple of hours, the germination taking place in the following manner: The contents of the spore undergoes a process of division, separating into a number of distinct particles, which very soon escape through an opening made in the spore-wall; they are then free, but exceedingly minute masses of naked protoplasm of

irregular outline. Attached to one side of each mass are two very fine, hair-like cilia, by the vibration of which it swims about in the water with an animal-like motion; hence these bodies have been named zoöspores. In from fifteen to twenty minutes the cilia fall off, the zoöspore comes to rest, assumes a definite outline, takes on a cell-wall, and immediately pushes out a prolongation or germinal tube, which penetrates the epidermis, and, continuing its growth within the tissues of the leaf, develops into what we have called the vegetative or mycelial portion of the fungus.

The germination by zoöspores is the most common, and perhaps we might say the normal habit of the *Peronospora* of the vine; and experience in culture leads to the belief that no form of germination will take place except in the presence of water. A damp atmosphere is insufficient; there must be the actual presence of water, in the form of drops of rain or dew, to effect the formation of the zoöspores.

Temperature exercises a considerable influence over the germination of the conidia, that which is most favorable being between 75° and 95° F. At lower temperatures germination takes place more slowly; but the temperature may be reduced to 32° without destroying the vitality of the conidia. Exactly how long these bodies will retain their vitality in a moist atmosphere has never been determined, but it is known that dry air, particularly a dry wind, is destructive to them. Experiments have shown that in a dry atmosphere the conidia contract in a very short time and shrivel up, or burst and lose their contents.

During the summer or season of growth the *Peronospora* expends its energies in the production of the conidia, whose office is the immediate dissemination and propagation of the fungus. To tide over the season of winter another spore-form is produced, which is furnished with thickened walls, and is still further protected by being embedded within the tissues of the host plant. These are the result of a special sexual process, and are termed oöspores, or, more popularly, "winter spores." Their formation begins as a slight swelling at the ends of branches of the mycelium. This swelling finally attains a diameter of about $\frac{1}{1000}$ of an inch, assumes a spherical shape, and the cell-wall covering it becomes thickened and pale yellow in color. At one side, arising from the branch that bears the oögonium or sack in which the oöspore is developed, another and smaller body is formed, which is termed the antheridium. The antheridium, without detaching itself from its support, comes into close contact with the oögonium at an early period, and later on, by a special mechanism, the granular protoplasmic contents of the former is doubtless conveyed to the latter, by which means it is fertilized, and the contents of the oögonium then develops into an oöspore.

The germination of the winter spore has never been satisfactorily determined; but, however it may take place, it probably does not occur until the spring or early summer following its formation.

ACTION OF THE FUNGUS.

On the leaves.—Pale green or yellowish spots of irregular size and outline appear upon the upper side of the leaves, and corresponding points on the lower surface soon exhibit the outside development—the spore-bearing filiaments of the fungus—in the form of white patches, that are very conspicuous on the smooth-leaved varieties of grapes. As the disease progresses the yellowish spots of the upper sur-

face assume a brownish hue, which gradually becomes more intense, finally having all the characters of completely dried and dead tissue. These spots may be quite small. Late in the season the older leaves attacked are often covered all over with minute brown spots, which are usually sharply defined, being limited by the nerves in the leaf; again, they may be so large as to nearly cover the whole surface, in which case the destruction of the leaf is quickly accomplished. Under the final action of the fungus the leaf becomes thoroughly dried and shriveled, as if burned, and the tissues are particularly brittle. It very rarely occurs that the mildew itself appears on the upper surface of the leaf.

On the shoots.—In severe cases the fungus extends to the young shoots, and, although the conidia-bearing filiaments do not appear excepting upon the youngest and most tender of these, the action of the mycelium checks their further development, and finally the tissues are killed. The effect upon the shoots is often to produce dark-colored, slightly depressed markings as a consequence of the sinking away of the tissues beneath. These markings are quite distinct from the deep and lacerated lesions of Anthracnose.

On the berries.—Berries when attacked early by the *Peronospora* rarely attain more than one-fourth their full size, often remaining no larger than small peas. They soon turn brown, or, when the fungus fruits upon them, gray in color. There is thus produced a kind of "rot," which is popularly named "brown rot," or "gray rot."

The berries of some of the varieties of grapes cultivated on the Department grounds were severely infested with the Downy Mildew last summer (1886). In some instances the peduncle was much swollen and distorted through the action of the mycelial growth within, and the fructiferous filaments or conidiophores of the *Peronospora* whitened here and there with a downy coating, the berries as well as the stalks supporting them.

REMEDIES.

Since the appearance of the Downy Mildew in France, in 1878, its ravages have increased in that country and extended throughout the grape-growing regions of Central and Southern Europe to such an alarming extent as to call for the exercise of every effort on the part of individuals and Governments to check or destroy it. Experments with remedies and preventives, begun in 1882, have been continued systematically in European vineyards, and the results obtained in 1885* were so satisfactory, that you considered them worthy of trial in this country, and for this purpose distributed last May the following circular to parties thought most likely to be interested in the subject:

U. S. DEPARTMENT OF AGRICULTURE.

Treatment of the Downy Grape Mildew (*Peronospora viticola*) and the Black-Rot (*Phoma uvicola*).

In view of the fact that Mildew and Black-Rot have been so destructive to the vine in this country that in some sections grape culture has become unprofitable and for this reason many are abandoning the business, the importance of making special efforts to discover effective remedies for these diseases will not be questioned.

With this object in view, the remedies which have recently been employed in

* For a detailed account of the use of these remedies in France and Italy in 1885, see special bulletin No. 2, Botanical Division, on the "Fungus Diseases of the Grape-Vine."

France and Italy with apparent success are here given, with the urgent request that one or more of them be tried, experimentally, and the results reported to this Department, so that the one which proves to be the most efficacious and economical may be made generally known.

Very respectfully,

NORMAN J. COLMAN,
Commissioner of Agriculture.

REMEDIES.

For Peronospora.

(1) Dissolve in 10 gallons of water 5 pounds of sulphate of copper. Soak the stakes and whatever may be used to tie up the vines in this solution, and as soon as the leaves are fully formed thoroughly spray them with the solution,* using for this purpose any fine spraying apparatus. The "cyclone nozzle," with fine aperture, described and illustrated in "Riley's report as Entomologist for 1883," is probably the best device for this purpose. Repeat the operation occasionally, say once in two or three weeks.

(2) Make a mixture of lime and water, as one ordinarily prepares whitewash. Apply this in the same manner as No. 1, using a nozzle with a large aperture. After rains the application should be renewed.

(3) In 22 gallons of water dissolve 18 pounds of sulphate of copper; in another vessel mix 34 pounds of lime with 6 or 7 gallons of water. Pour the lime mixture into the copper solution; mix thoroughly, and the compound is ready for use.† Placed in conveniently sized buckets, it may be carried through the rows of the vineyard and applied to the leaves by the aid of brooms or whisps made of slender twigs dipped into the compound and then switched right and left so as to spray the foliage.

This remedy is very highly recommended. It is not necessary to entirely cover the leaves. Care must be taken not to get any of the compound on the berries.‡

(4) The powder of Mr. Podechard. This powder contains the following ingredients, in the proportions given: 225 pounds of air-slaked lime, 45 pounds of sulphate of copper, 20 pounds of sulphur (powdered), 30 pounds of ashes (unleached), and 15 gallons of water.

These ingredients are compounded as follows: Dissolve the sulphate of copper in the water; when thoroughly dissolved pour the solution upon the lime, which is surrounded by the ashes to keep the liquor from spreading; after twenty-four hours add the sulphur, thoroughly mix the compound, ashes and all, and when dry sift through a sieve with meshes of one-eighth of an inch. This preparation may be made several months before it is required for use. Its application is made simply by dusting it upon the foliage of the vines after a heavy dew or rain with any spraying or dusting device, that figured and described in the report of the Entomologist for 1883 being well adapted to this purpose. The convenience of application renders this powder especially well suited for use in the larger vineyards.

(5) The ordinary milk-kerosene emulsion (see Report of U. S. Entomologist, 1884, p. 331), with the addition of from 2 to 5 per cent. of carbolic acid and the same percentage of glycerine, and then diluted in 20 to 50 parts of water to 1 of the emulsion. Spray on the under surface of the leaves by means of a cyclone nozzle of small aperture. This is known in France, where its use has been attended with satisfactory results, as the "Riley process," having first been proposed by Dr. C. V. Riley.

For Black-Rot.

The free application of the sulphate of copper and lime appears not only to act as a preventive against Mildew, but Black-Rot also. As a further protection against the latter disease it is recommended that Podechard's powder be scattered over the grounds in the vineyard, especially where all the trimmings and fallen grapes and leaves of the previous year have not been removed.

Three thousand of these circulars were distributed, and I have reason to believe that many made a trial of one or more of the remedies proposed, but I regret to say that few responded to the request that the results of these trials be reported to the Department. It is hoped

* The solution for spraying the vines here given is too strong. One pound of sulphate of copper to 20 gallons of water is strong enough.

† This is the copper mixture of Gironde, or Bordeaux mixture.

‡ This precaution is uncalled for, except at the approach of the vintage.

that another season there will be a more hearty co-operation between the vineyardists and Department in this work.

One correspondent, George M. High, Middle Bass, Ohio, in a letter under the date of December 28, says:

Early last spring I received a circular from you, asking me to make some experiments with remedies for the destruction of Mildew and Black-Rot.

On the 13th of June I sprinkled lime water, as directed in No. 2 of instructions, upon 1 acre of Catawbas, about 1,000 vines. There was a heavy rain on the 24th, washing the lime from the foliage. The weather became quite hot, so on the 28th I again sprinkled the vines. No perceptible advantage over vines alongside not treated. Also upon 400 vines, both upon foliage and on ground under vineyard rows, I sprinkled air-slaked lime June 7, 14, 22; July 5, 23; and August 9, with but very slight beneficial results, if any. I imagined the wood ripened somewhat better than upon untreated vines.

Sulphate of copper and lime were applied as directed in remedy No. 3 with results that convince one that, with proper application, this remedy will prove more beneficial than anything yet known here for Mildew and Black-Rot. Fourteen vines were selected—8 together, the balance in different parts of vineyard, 12 Catawbas and 2 Noahs.

The first application was made June 14, spattering the foliage very thoroughly. There was considerable rain on 20th and 21st instant, not entirely washing the leaves clean. On 22d made a second application. First Mildew was observed 22d of July; on the 23d I again put on the sulphate of copper and lime mixture, although the previous application was yet quite perceptible upon the foliage. Of the vines so treated not one was affected by either Mildew or Rot, the foliage holding its natural color long after that on other vines had become brown and seared; the wood and grapes ripened thoroughly. A Noah vine, upon which for several years the berries had rotted more or less and dropped from the cluster about the time of ripening, bore this season over 40 pounds of grapes of good quality.

The coming season I will give this remedy a more thorough trial, feeling satisfied that it will prove effectual if applied in time. My impression is that two applications would be ample, the first soon after bloom or first indications of Mildew, the second about the middle to last of July.

I also treated 60 Catawbas with a preparation made as follows: Dissolve 1 pound of sulphate of copper in 2 gallons of water; in another vessel slake 4 pounds of lime in the same quantity of water; then mix these together thoroughly. The advantage was the preservation of the foliage in a healthy condition in a marked degree over vines untreated.

Bush & Son & Meissner, of Missouri, say:

We have tried all the remedies recommended in your circular and find that designated as No. 3 to be the best. We are continuing to apply this mixture of lime with dissolved sulphate of copper (not too strong) with confidence in its good results.

Another correspondent states that he has used Podechard's powder (No. 4) with marked benefit.

MILDEW REMEDIES IN FRANCE IN 1886.

The results obtained in France in 1886 by the use of cupric fungicides for *Peronospora viticola* fully confirm previous statements and experiments. Those detailed by Mr. Millardet in *Journal d'Agriculture Pratique*, November 25, 1886, are especially interesting. The experiments at Dauzac and Beaucaillou were conducted either by himself or by Mr. David. Eighteen remedial mixtures, dry or fluid, were tried very carefully with the necessary control experiments, and full memoranda were made from time to time of the condition of the various plots. The experimental fields covered in all about 5 acres. The most important results are given in the following tabular abstract, compiled from the report in the *Journal*. It will be seen that the most completely protective substances were: The copper mixture of Gironde; David's powder; Podechard's powder; mixture of sulphate of copper and plaster; cupric steatite (a bluish-white unctuous powder, composed of steatite and sulphate of

copper); and sulphatine (a secret mixture of sulphur, lime, sulphate of copper, and plaster).

Table showing results of experiments of Millardet and David with Mildew remedies in France in 1886.

[In the second and third columns the scale is 10, zero indicating total destruction of foliage and 10 entire preservation. The small figure at the right and above denotes the number of times the remedy was applied.]

Kind of remedy.	Results.			Remarks.
	Condition of foliage in field of Malbecs, at Dauzac, October 14, 1886.	Condition of foliage in field of Cabernet-Franc, at Beaucaillou, October 11, 1886.	Sugar, per liter, in must, from plot of Cabernet-Sauvignon, at Beaucaillou. Grapes all gathered October 1, 1886.	
No treatment	0	0	113.6	
Copper mixture of Gironde	9^{3}	8^{3}	196.0^{3}	
Copper mixture of Gironde, different formula	9^{3}	9^{3}	192.2^{3}	
Copper mixture of Gironde, with addition of glue	3^{1}	9^{3}	187.0^{3}	
Eau céleste, or Audoynaud liquid *	3^{2}	1^{1}	153.8^{2}	These remedies were used only once or twice at Beaucaillou, because of great injury done to foliage of the vines. The vines at Dauzac, upon which these were repeatedly used, were in some cases so much injured that the grapes did not ripen.
Eau céleste, Mr. Gayon's formula	3^{2}	4^{1}	138.0^{2}	
Solution of sulphate of copper, ½ per cent	3^{3}	2^{1}	138.8^{2}	
Solution of sulphate of copper, 1 per cent	4^{4}	2^{1}	160.0^{2}	
Solution of sulphate of copper, 2 per cent	4^{5}	5^{1}	146.0^{2}	
Solution of sulphate of copper, 3 per cent	4^{6}	5^{1}	169.4^{2}	
Solution of sulphate of copper, 4 per cent	4^{7}	5^{1}	153.8^{2}	
Milk of lime, 15 per cent	1^{4}	1^{3}	153.8^{3}	
Milk of lime, 3 per cent	0^{4}	1^{3}	135.2^{3}	
Quick-lime, slaked and sifted	1^{4}	0^{5}	156.2^{5}	
David's powder †	8^{4}	9^{5}	200.0^{5}	
Podechard's powder	5^{4}	8^{5}	196.0^{5}	
Mixture of plaster and sulphate of copper ‡	4^{4}	7^{5}	188.6^{5}	
Sulpho-steatite, or cupric steatite	7^{4}	8^{5}	187.0^{5}	
Sulphatine (secret compound)	7^{4}	8^{5}	210.6^{5}	

*For formula of Eau céleste, see p. 103, under "Audoynaud process."

†David's powder is made as follows: Slake 66 pounds of lime in the least possible amount of water, and dissolve 17½ pounds of sulphate of copper in the smallest quantity of water necessary to effect its solution. Mix the latter with the lime when it is *completely cooled*. Let the compound dry in the sun, then crush and sift it, when it is ready for use.

‡The plaster and sulphate of copper remedy is composed of 66 pounds of plaster and 17 pounds of sulphate of copper. The copper salt is dissolved in the least possible amount of water, and then poured upon the plaster. Mix thoroughly, dry in the sun, crush, and sift.

In a letter to Prof. C. V. Riley, U. S. Entomologist, M. G. Foëx, of the National School of Agricu ture at Montpellier, France, under date of November 30, 1886, having reference to the results and conclusions reached at the International Congress mentioned below, says:

The most interesting portion of the meeting at Florence was the discussions relative to the treatment of the Mildew. The efficacy of the salts of copper was boldly proclaimed.

The best formulæ given are:

(1) *Bordeaux mixture.**—The vines are sprinkled during their vegetation with a mixture of sulphate of copper and lime, prepared as follows:

In 100 liters † of water dissolve 6 to 8 kilograms ‡ of sulphate of copper; in another

*The same as the "Copper mixture of Gironde." Equals No. 3 in the circular of remedies above quoted, with a slight reduction in the quantity of sulphate of copper used.

†One liter = 1.76 pints. ‡One kilogram or kilo = 2.2 pounds.

vessel 15 kilograms of air-slaked lime are mixed in 30 liters of water. When the sulphate of copper is completely dissolved and the lime forms a homogeneous mixture, the latter is poured into the sulphate of copper solution, the mixture being stirred in the preparation. There is thus obtained a clear blue precipitate, which settles to the bottom of the vessel. This precipitate should be stirred up at the time of using, to put it in suspension in the water.*

(2) *Audoynaud process.*—M. Audoynaud, professor of chemistry in our school, has proposed to sprinkle the leaves with ammoniacal sulphate of copper. This liquid is made in the following manner: In a stoneware or glass vessel 2 or 3 liters of warm water are poured upon a kilogram of sulphate of copper, which is stirred with a wooden or glass rod to hasten solution. When cooled, a liter of commercial ammonia is added. This liquid is finally mixed in a suitable cask with sufficient water to make 200 liters, which serve for the treatment of one hectare.† The application of this liquid is made by means of the Riley sprayer.

(3) *Sulphated sulphur.*—M. Theophile Skawinski, at Chateau Laujac, in Gironde, and M. D. Cavazza, director of the school of viticulture at Alba (Piedmont), have used successfully mixtures of pulverized sulphur with 8 to 10 per cent. of sulphate of copper finely triturated.

These three remedies have shown themselves efficacious, but the one which appears thus far to have given the most security from the Mildew is the second. It has the advantage of adhering strongly to the leaves, remaining upon them until their fall. The salts of copper, thus applied to the leaves, act by preventing the germination of the conidia, and consequently the development of the *Peronospora.*

By referring to the table showing the results of the experiments of Messrs. Millardet and David, it will be seen that the Audoynaud liquid (*Eau céleste*) did not give good results in their hands, and, besides, its application injuriously affected the foliage.

In October last (1886) there was held at Florence, Italy, an international congress for the "exhibition of machines and apparatus for the preparation, transportation, distribution, and application of remedies against fungi and insects." At the same time there were held a number of special meetings for the discussion of the fungus diseases of the vine and the remedies to be employed against them. According to an official report of these meetings, the conclusions in respect to remedies were: (1) That gaseous remedies applied against the *Pe-*

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*In respect to this remedy Professor Foëx, in an article in the June number (1886) of *La Vigne Américaine*, says:

"Its action is due to the copper which it contains. The presence of this metal, even in a very minute quantity, in drops of dew or rain on the upper surface of the leaves, prevents the germination of the conidial spores which may have been brought there by the wind. Thus forestalled, the disease cannot establish itself upon the leaves.

"*Mode of application.*—The copper mixture should be distributed by sprinkling in little drops on the upper surface of the leaves. Two or three spots thus produced suffice to completely preserve a leaf, and they become sufficiently adherent and coherent, as soon as they have dried, to remain until the leaves fall.

"The sprinklings were made in Gironde, in 1885, with a simple broom of heath, which was plunged into a bucket or watering-pot containing the mixture. This plan of operating gives satisfaction so far as the distribution of the substance is concerned, but it has the inconvenience of being somewhat slow, and it requires much hand labor; therefore apparatuses have been devised which permit more rapid operation at a less expense of muscle. The one which gave the best results at the trial held in Montpellier, in February, 1886, was that of Mr. Delord, 9 Rue St., Gilles, Nimes.

"*Time when the treatment should be made.*—The salts of copper having the effect, as we have seen, of preventing the disease from becoming established, their use should be preventive. The vines should, therefore, be treated before May 15, at which date the *Peronospora* has sometimes made its appearance in certain places in the Department of Herault. In operating at so early a date only a small portion of the leaves can be reached, the greater number developing between this period and the 1st of June. In practice, therefore, it is better probably to sacrifice, if need be, some of the first leaves, and make the treatment only when the vegetation has reached a sufficient development, say, in Herault from the 1st to the 15th of June."

†One hectare = about 2½ acres.

ronospora have not given any useful results; (2) that among the remedies in the form of powder thus far tried the most efficacious are those in which sulphate of copper is used; (3) that the mixture of lime and ashes and of lime and sulphur have not as yet given results sufficiently satisfactory to enable us to recommend their use; (4) among the liquid remedies, the milk of lime, prepared so as to make it convenient for application, has proven quite satisfactory. However, its use from a practical and economic standpoint encounters in many places serious difficulties; (5) that the remedies most successful in the results obtained are the mixed liquids or solutions containing sulphate of copper.

It was further concluded that the action of the remedies is *preventive;* therefore only the preventive application can check the invasion of the Mildew, and repeated applications act only in so far as they prevent future invasions of the disease. In localities much subject to the Mildew it is necessary to apply the remedies to the vine before the season of bloom, and in all places it is needful to apply them with the greatest thoroughness as soon as the Mildew appears, and to repeat the application according to the necessities and the nature of the remedy.

No evidence was adduced showing that the applications of the salts of copper to the vine had resulted in injury to the public health.

A simple solution of sulphate of copper, 300 to 500 grams to the hectoliter* of water, has proved in some instances to be equally effective in warding off the Mildew as the copper mixture of Gironde. As its application is attended with much less inconvenience and expense, further trials should be made to determine its relative value. This solution, like all others, should be applied preventively, say about June 15, unless the Mildew appears earlier; a second application being made about the 1st of August.†

SKAWINSKI'S POWDER FOR COMBATING THE MILDEW ALONE, OR THE MILDEW AND THE OÏDIUM TOGETHER.‡

Having determined the value of sulphate of copper as a remedy for the Mildew, Mr. Skawinski, a viticulturist of Chateau-Giscours, France, experimented, with the view of discovering means for fixing the particles of this salt upon the leaves of the vine. He discovered that coal dust or calcined alluvial earth, added in proper proportions to the finely triturated sulphate of copper, gave to it the quality of adherence desired.

The compound for the treatment of the Mildew alone consists of sulphate of copper, finely powdered, 10 kilograms; soot or alluvial earth, 15 kilograms; coal dust, 75 kilograms.

For combating the Mildew and the Oïdium: Sulphate of copper, 10 kilograms; sulphur, 50 kilograms; coal dust, 32 kilograms; soot or calcined alluvial earth, 3 kilograms.

The first treatment should be made when the shoots are about 6 inches long; a second may be given at the time of flowering; a third, when the berry is formed; and a fourth, at the time of ripening of the fruit.

*One hectoliter = 22 gals.

†The application of the sulphate of copper compounds for preventing Mildew should be made in cloudy or rainy weather, for at such times the danger of corrosion from a too rapid evaporation of the solutions is avoided, and they will also be more evenly and thoroughly distributed over the surface of the leaves.

‡*La Vigne Américaine*, November, 1886.

Five kilograms of the powder is about the quantity required for an acre of vines. It is applied with an ordinary sulphuring-bellows.

The value of the Bordeaux mixture, or, as we have come to term it, the copper mixture of Gironde, has been settled beyond dispute, but there are certain factors which may determine the degree of the success in its use which ought to be considered. These are, the careful preparation of the mixture; the time of its application; the more or less intelligent manner in which the spraying has been made; the atmospheric conditions of rain or dryness existing at the time or which may follow the operation; the number of treatments made; and the purity of the sulphate of copper used.

These are all points which should be carefully noted in experimenting with this and the other remedies proposed, especially in determining their relative value as fungicides.

In the hands of some grape-growers a remedy may seem to give excellent results, but before it receives unqualified recommendation it must be tried in many localities and during a series of years, in order to eliminate all sources of error. Many cases of apparent benefit from the applications may be solely due to accident, such as changes in the weather or some other cause not within the control of the grower. If applications are made to the vines in years when, from dryness or other natural cause, fungi of all sorts are unusually scarce, then, unless very carefully conducted control experiments are made at the same time, it is easy to see how results due solely to the season or location might be ascribed to the remedy, and false conclusions arise. Hasty generalizations from a few observations and experiments are very common, but the careful investigator will not be deceived by them. In reference to all proposed remedies, it may be said only when the disappearance of the fungus uniformly follows the application of the remedy are we warranted in attributing this to its use.

II.—The Powdery Mildew.

Uncinula spiralis, B. and C.

(Plate II.)

Like the Downy Mildew, the Powdery Mildew of the vine is a native of this country, and attacks the foliage, young shoots, and berries of both the wild and cultivated varieties of the grape, showing a decided preference to those of the *Vinifera* class. Here the resemblance ceases, however, for the *Uncinula* is a fungus of a very different habit of growth from the *Peronospora,* and belongs to an entirely distinct group of parasites—a group embracing what are familiarly referred to as the White Mildews or Blights, of which the common Grass Mildew (*Erysiphe graminis*), the Lilac Mildew (*Microsphæria Friesii*), and the too well known Mildew of the Hop-vine are examples. The diversity extends even to the climatic conditions favoring the growth of these two fungi; for, while a liberal supply of moisture is necessary to the full development of the *Peronspora,* the *Uncinula* likes a comparatively dry atmosphere, and always occasions most injury during seasons of protracted drought. It has long been known as a serious pest in California, and is nowhere entirely absent in the region east of the Mississippi. In the average season, however, it does comparatively little injury in the open vine-

yard—at least the injury is slight as compared with that wrought by the Downy Mildew.

This season I have observed it in all its phases of development, both upon vines in the open air and upon those cultivated under glass here at the Department. Upon the foreign varieties in the grapery it was most abundant and its injurious effects most apparent.

The term "Powdery Grape-Vine Mildew" was first applied to this fungus by Prof. C. V. Riley,* and as it is descriptive, and at the same time clearly distinguishes this mildew from *Peronospora viticola*, to which the same author has applied the name of "Downy Mildew," it has been employed here, with the hope that it may become generally adopted by those who prefer English to Latin names.

It has frequently been discussed in our agricultural and horticultural journals for many years past under the name of "*Oïdium Tuckeri*," or simply "*Oïdium*," it being supposed that our fungus was the same as the European vine mildew of that name, but whether the European *Oïdium* is the same as our *Uncinula* or not is yet a matter of question, owing to the fact that the mature or fruiting form of the first named has never been discovered, the conidial stage alone being known. De Bary has suggested that the European *Oïdium* is an importation from America. He says: †

> Concerning its first appearance and spread in Europe, it can be accepted as certain that it was transported suddenly from some other flowering species introduced into our vineyards from abroad. *Most probably its immigration is from America.* [The italics are mine.—F. L. S.] In spite of its destructive spreading over the whole vine-growing portion of Europe, the most careful investigations in this country have nowhere led to the discovery of any indication of perithecia; the entire invasion takes place by means of the conidia, produced in great abundance, the form of which has procured the fungus the name of *Oïdium* (*O. Tuckeri*). The perithecia are probably found in North America on the native sorts of *Vitis*, and have been described as *E.* (*Uncinula*) *spiralis*, Berk. and Curtis; yet this is not certain.

The Powdery Mildew consists of a mycelial growth, that rests wholly upon the surface of the parts of the vine supporting it, and the reproductive bodies or spores, of which there are two kinds. The threads or hyphæ of the mycelium have a uniform diameter of about $\frac{1}{6000}$ of an inch, are much branched and interlaced, and are provided with frequent septa or cross-walls. Where this mycelium is applied directly to the epidermis of the supporting plant there are developed at short intervals irregular protuberances or suckers, by which the fungus fastens itself to the host and through which it imbibes its nourishment.

If the fungus be examined early in the season, say in June or early in July, short branches will be seen arising from the threads at right angles, or nearly so, to the plane of their growth. The branches are divided into several oblong cells by cross-walls. The uppermost cell is slightly larger than that immediately below it and is rounded at its upper extremity. If this terminal cell be watched we will soon see its lower end becoming rounded like the upper, forming thus a stricture between it and the next cell below, from which it is soon completely separated and falls off. The next cell of the branch quickly passes through the same changes noted in the first, and in this way a number of conidia are formed in rapid succession. Like the conidia of the *Peronospora*, those of the *Uncinula* serve for the immediate propagation and dissemination of the fungus; but damp-

*Proc. Amer. Pom. Soc., session of 1885, p. 49.
†Verg. Morph. u. Biol. der Pilze, &c., pp. 244–245.

ness, or a moderate amount of humidity only, is sufficient for their germination. They do not require water condensed in the form of drops of rain or dew, as does the Downy Mildew, and they germinate by the immediate production of germ-tubes and not by zoöspores. The conidia are thin-walled, oblong cells, filled with a transparent granular matter. One of these bodies falling upon a grape-leaf will, under favorable conditions of temperature and humidity, push forth one or more germ-tubes, which first send haustoria, or suckers, into the epidermal cells and then grow into the thread-like branched mycelial formation (thallus) diffused over the surface. By their multitude these threads now become visible to the unaided eye, and we have what has been familiarly termed "Mildew," "*Erysiphe*," "*Oïdium*," &c.

When the mycelial growth has attained its full development a spore formation of an entirely different character from that above described takes place. Perithecia, or what we may be allowed to term "fruits," are formed, within which spores are produced in a number of little sacs called asci. These "fruits" are especially abundant on the invaded organs of the vine during the months of September and October. To the naked eye they appear as minute dark-brown or black points, thickly dotting the mildewed surface. (One of these bodies is figured in Plate II. The appendages which surround the perithecium usually stand up at quite an angle to the plane of their attachment; they do not lay out flat, as represented in the figure.)

In their growth the perithecia are at first quite colorless, then pale yellow, and finally very dark brown or black. The appendages are clear and transparent at their extremities, but have a brownish color towards their bases. They are divided into several cells by transverse walls, and are sometimes, though rarely, branched or divided above.

The asci, developed within the perithecium, are delicately walled, transparent sacs that contain the ascospores or sporidia. These are oblong bodies, rather more rounded in outline than the conidia and somewhat smaller. They are the true winter spores of the fungus. Closely incased within the hard, compact walls of the perithecium, they are well protected from injury and the severe weather of winter. In the spring the walls of the perithecium decay or crack open, allowing the sporidia to escape, and bring about a new infection of the vines. Doubtless a sufficient number of these fungus fruits remain adhering to the vines through the winter to bring about a recurrence of the disease as soon as the conditions favorable to the germination of the sporidia prevail.

ACTION OF THE POWDERY MILDEW ON THE VINE.

The Powdery Mildew makes its appearance usually during the early days of June and continues its development late into the autumn. It appears in dull, grayish-white patches, most conspicuous on the upper surface of the leaves, and when growing thickly on the young shoots or berries its mycelium imparts to these organs a similar hue. It never has the bright, lustrous, or frosty appearance that characterizes the Downy Mildew, and the livid brown or seemingly scorched blotches on the leaves that the latter fungus occasions are wanting, although in thin-leaved varieties of foreign vines a discoloration takes place through the whole thickness of the leaf, visible at the points below the patches of fungus growth on the surface above. In a few instances I have seen the mycelial growth so dense upon the

leaves as to give them the appearance of having been spattered and blotched with whitewash, the spots being a pure dead white. This mildew is also found on the lower surface of the leaves, but never to the same extent as upon the upper side; and as it is only in the latter part of the season that it has been observed there at all, its presence is doubtless due to an extension of growth from other parts, as from the petiole.

Upon the young and tender shoots the fungus is often particularly abundant, its action being to check their growth. Its presence on the older and half-ripened shoots is indicated by distinct but irregular brownish blotches in the epidermis. Sometimes the *Uncinula* appears during the season of bloom, and, coming on the newly expanded flowers, causes them to abort. Attacking very young berries when these are no larger than shot or small peas, their growth is permanently checked. Cases have come under my observation where the *Peronospora*, the *Uncinula*, and the fungus of the Black-Rot were all engaged in their work of destruction upon a single bunch of grapes. It is needless to say that the destruction was complete.

Upon the older berries the presence of the Powdery Mildew is made evident before the mycelial threads have obtained sufficient growth to become conspicuous themselves by the minute brownish spots produced by the action of the suckers on the epidermal cells. These spots eventually become confluent, the epidermis dies or is so affected that it will no longer expand with the growth of the berry and consequently bursts, first forming tiny, then gaping tears, the result being the death and decay of the berry. Oftentimes the fungus spreads over only a small portion of the berry; this part ceases to grow, and a much distorted or imperfectly formed fruit is the result. The distortions are often carried so far that the berries crack open, exposing the seeds. We sometimes find nearly full-grown berries completely overgrown with the mycelium of the *Uncinula*, so that the brown specks above mentioned, if present at all, are completely hid from view. These berries eventually become dry and shriveled and finally drop off.

REMEDIES.

The flowers of sulphur is an efficient and the usual remedy employed for this form of Mildew.

It is not necessary to bring the particles of sulphur into immediate contact with the spores and fungus threads to effect their destruction; the fumes which this substance emits at elevated temperatures will accomplish this. The knowledge that heat favors the production of these fumes makes it obvious that the best time to make the application is when the thermometer stands the highest. The fumes are given off rapidly when the temperature ranges between 75° and 95° F. The higher the temperature the more abundant are these fumes, and consequently the more rapid will be the destruction of the parasite. In latitudes where the soil temperature reaches 110° to 120° during the day it has been found that spreading the sulphur on the ground under the vines is sufficient to accomplish the destruction of the mildew, and a like result is obtained by dusting the sulphur over the hot-water pipes in the grapery, providing these be sufficiently heated.

If the sulphuring be delayed until the formation of the perithecia it is not likely to do much good, for although it may destroy the mycelial threads, the ascospores are too well protected within their hard coverings to be injured by the application.

The time when the sulphur should be employed is in early summer, at the first appearance of the Mildew, and the application is most effective when made on a warm, bright day, after all dew has evaporated. However well this application may be made, it is almost certain that some of the fungus threads and many of the conidia will escape destruction. From these, or from spores brought from other vineyards, a new infection may appear in from twenty to thirty days, when a second sulphuring should be made.

In districts particularly subject to this disease it is recommended that the vines be sulphured—first, when the young shoots are about 4 inches long; second, at the time of blossoming; third, some days before the turning of the berries. In bad seasons the mildew may make its appearance between these periods, when of course additional sulphurings should be made. Particular emphasis is placed upon the sulphuring at the time of bloom, for the flowers are almost certain to be rendered sterile if attacked by the *Uncinula*, and every precaution should be taken to prevent, if possible, the development of the Mildew at this time.

III.—Black-Rot.

Physalospora Bidwellii, Sacc.

(Plate III.)

The Black-Rot of the grape is a disease familiar to all grape-growers of the Middle Atlantic and Central States. It is known to prevail with greater or less severity—in some instances causing the total destruction of the grape crop—in Alabama, Georgia, Illinois, Indiana, Maryland, Michigan, Mississippi, Missouri, North Carolina, South Carolina, New Jersey, Ohio, Pennsylvania, Tennessee, Virginia, and Kansas.

It is now more than twenty-five years since Dr. George Engelmann, in a paper communicated to the Saint Louis Academy of Sciences, clearly pointed out the characters of this rot and described the active stage of the fungus which produces it. A great deal has been written and published concerning this disease in more recent years, but very little additional information has been acquired. The atmospheric conditions favoring its development had already been pointed out, and the fact that certain varieties were more subject to it than others had already been noted, while to-day we are yet looking for an efficacious remedy.

The first manifestation of Black-Rot is the appearance of a livid brown spot on some part of the berry; this spot gradually increases in size until the entire grape is uniformly discolored, so that it appears to be rotten, although its original contour and firmness are retained. It usually happens that before the completion of this change the part first affected becomes darker in color, and minute black pimples are developed over the surface. At the same point the berry now begins to lose its fullness, an irregular depression appears, which soon extends into a general withering of the berry, the pimples meanwhile having multiplied so rapidly as to cover its entire surface. The destruction of the berry is now complete; it is hard, dry, shriveled to one-half or one-fourth its original size, the folds of the skin being closely pressed upon the seeds and raised into strong, prominent, and irregular ridges. These last and the little pimples, which are easily seen with the naked

eye, are characteristic of this form of rot. The rotted berries remain firmly attached to their supports for a long time, sometimes even till the following spring.

The manifestations of the Black-Rot do not always appear as detailed above, for not infrequently the first evidence of the disease is the sudden appearance of one or more circular, slightly depressed spots, of a bluish-black color, in the center of which there soon appear a few of the little pimples or pustules above referred to. These spots increase in size, the pimples in number, and ere long the berry exhibits the black and shriveled appearance already described.

These changes are effected in from one to five days, varying with the atmospheric conditions.

The fungus of the Black-Rot is figured in detail in Plate III. It consists of a vegetative or mycelial growth, which pervades the tissues of the berry, turning them brown and ultimately destroying or absorbing their contents, and of several distinct forms of reproductive bodies or spores.

During the earlier stages of the disease the mycelium is most abundant near the surface of the berry, and here, at frequent points, just beneath the cuticle, it makes a condensed growth, resulting in the formation of the perithecia or conceptacles destined to contain the spores. In their development these conceptacles raise and finally burst through the cuticle, imparting to the surface of the berry the pimply or pustulous appearance mentioned above. At the apex of the exposed part of each conceptacle there is a minute opening or osteolum through which the spores escape at maturity.

The spores are pushed out, probably by the absorption of water, in the form of minute worm-like threads, being held together by a kind of mucilage. (See Fig. 1, Plate III.)

The conceptacles found upon a newly diseased berry are of two sorts; one contains oval or oblong spores, named stylospores, and the other contains much smaller cylindrical spores, called spermatia. These two sorts may form distinct pustules or they may be united in the same stroma,* as illustrated in Fig. 2, Plate III.

The stylospores germinate freely in water within a space of three or four hours. They throw out a slender tube, which soon provides itself with septa, branches, and quickly develops into a mycelium in every way like that seen within the tissues of the berry. How long these stylospores may retain their germinative power is unknown, but it is not likely that they hold it through the winter season. Their office is undoubtedly to effect the immediate propagation of the fungus.

What may be the rôle of the spermatia in the economy of the fungus is a matter of speculation. Their very small size and consequent lightness have suggested to the minds of some that their office is to more certainly effect the wide distribution of the fungus. In speaking of these bodies in general, in the order *Pyrenomycetes*, Cornu says: "They are true spores, since they germinate and give out filaments, having all the appearance of mycelial threads." He regards them as very small conidia, of a special form, borne upon particular arbuscles in protecting conceptacles. They do not in general germinate in pure water, and they have a rather slow development. Their physiological rôle appears to be determined by their very small size and the circumstances which their germination requires.

If the exposed surfaces of the conceptacles above mentioned are

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*Stroma, the substance in which the perithecia of some fungi are immersed.

carefully examined, especially after a period of very damp weather, one will often find arising from them short stalks or conidiophores, bearing very small oval conidia. This growth is illustrated in Fig. 4, Plate III.

The discovery of the mature or ascigerous form of the fungus of the Black-Rot is recorded in the "Bulletin of the Torrey Botanical Club for August, 1880." It appears that Dr. E. C. Bidwell, of Vineland, N. J., made this discovery in the early part of May of that year (1880) in grapes which had been diseased with the rot the season previous. At about the same time Mr. J. B. Ellis, the well-known mycologist of Newfield, N. J., found the same form in the old and shriveled grapes gathered from the ground in vineyards at his place. This mature or ascigerous form of the fungus of the Black-Rot is shown in Fig. 6, Plate III, drawn from specimens very kindly sent me by Mr. Ellis.

Within the conceptacle or perithecium are seen a multitude of little sacs, named asci, in which are developed spores that are technically called sporidia or ascospores.

The walls of the asci are very transparent, and it is difficult to determine their outline, except they be separated and viewed singly. (Figs. 7 and 8, Plate III.) Except for the sporidia they contain they are perfectly transparent.

The perithecia containing the asci are in all respects like those that inclose the stylospores, and they have every appearance of being developed from the same mycelium, which doubtless retains its vitality through the winter months within the diseased berries.

To sum up the life history of the fungus of the Black-Rot we have: (1) The stylospores, inclosed in conceptacles, the *Phoma uvicola* of authors; (2) the spermatia, produced at the same time and inclosed in similar though smaller conceptacles; (3) the conidia, externally developed on short conidiophores; and (4) the sporidia, which are formed in asci that are inclosed in a protecting perithecium. The stylospores, and possibly also the spermatia, are undoubtedly designed for the immediate propagation of the fungus. The conidia probably serve the same purpose, and by their tardy development may help to continue the fungus from year to year. The sporidia, without doubt, are the special reproductive bodies for the latter purpose, being analogous to what have already been named "winter spores."

When the mature form of this fungus was discovered, Mr. Ellis named it, in honor of the discoverer, *Sphœria Bidwellii*. A more recent system of classification has placed it in the genus *Physalospora*, and it is now known to mycologists as *Physalospora Bidwellii* Sacc.

REMEDIES.

It is plainly evident from the nature of the fungus of the Black-Rot that all remedies must be preventive. When the mycelium is once established in the tissues of the berry the destruction of the latter is certain.

It is now known that the fungus passes the winter in the diseased and withered berries of the previous season, and possibly also in the young shoots. Hence, by gathering and raking together in the autumn all the fallen berries and trimmings from the vine and burning them, just so much infectious material will be destroyed. The washing of the vines in early spring, before the buds have commenced

to swell, with a strong solution of sulphate of iron may assist in this work of prevention by destroying the disease germs, and it is quite possible that the remedies advocated for combating the Downy Mildew—the copper mixture of Gironde or David's powder—may prove of value in preventing this Black-Rot.

For many years it has been the practice among vineyardists to protect certain varieties of grapes, designed especially for exhibition, from the depredations of birds and insects by inclosing the young bunches in paper bags. It was observed that grapes thus covered escaped the Black-Rot, when those exposed were entirely destroyed. From this discovery the "paper-bag remedy" soon came to be generally advocated, and to-day we know of no more economical and certain means of preventing the Black-Rot than that of inclosing the half-grown bunches in paper bags. Two-pound brown-paper bags, costing about $1.25 per 1,000, may be used; these are drawn over the bunches and tied or pinned around the stems.

ANTHRACNOSE.

Sphaceloma ampelinum, De By.

(Plate IV.)

In so far as we have any evidence, this is a comparatively new disease in this country, and one which is likely to seriously affect the grape interests in the Middle and Central States, if not held in check by prompt treatment. It has already become distributed over a wide extent of territory. Specimens exhibiting this disease were received at the Department the past season from South Carolina, Michigan, Illinois, Delaware, and New Jersey. Prof. T. J. Burrill, of Champaign, Ill., first observed it in Central Illinois in 1881, and afterwards in many localities in that State; also in Indiana, near Indianapolis; in Michigan, at Lansing; and in Ohio, at Cleveland. All the samples received affected with this disease were of white or light-colored varieties. The berries of the Elvira, in one instance, were entirely destroyed by it.

In Europe it has been known for many years, and has received various names, as "Charbon," "Brenner," "Schwarze Brenner," "Pech," &c., but that which has come into most general use is "Anthracnose," derived from the two Greek words, for "coal" and "disease."

Anthracnose, like the Black-Rot, is caused by a minute fungus, the habit of which, however, is radically different from the fungus of that disease, as are also the external changes which it induces. All the green parts of the vine are subject to its attacks from the beginning of spring vegetation until the close of the growing season, and, when very abundant, the injury occasioned to the young shoots is quite as serious as its action on the fruit.

EXTERNAL CHARACTERS.

The external characters of Anthracnose are determined by the growth of a special fungus, as has been demonstrated by inoculations or sowings of the fungus spores upon healthy shoots and berries.

On the shoots.—There first appear minute brown spots, a little depressed in the middle, with a slightly raised dark-colored rim or border. These spots increase in size, elongating in the direction of the

striæ of the bark, the central portion becomes more evidently destroyed, and in severe cases the woody tissues beneath appear as if burned or corroded, so deeply sometimes as to reach the pith.

On the leaves.—The action of the fungus on the leaves is similar to that upon the stems, and it is certainly very evident that where the diseased spots are numerous and the development of the fungus proceeds without interruption both shoots and leaves must succumb to the parasite. The intensity of the disease upon the shoots may cause the destruction of the young leaves even when the latter are not directly attacked.

On the berries.—So far as my own observations are concerned, the severity of this disease has been especially marked upon the fruit. In order to appreciate the full extent of the injury occasioned to the berry one has only to consult Plate IV, Fig. 1, which represents a bunch of Elvira received from Mr. Wanner, of South Carolina, affected with Anthracnose. The progressive stages of the malady are fully illustrated; a little to the left of the center is a berry showing the first external manifestations of the disease. There is a small spot, grayish in the center, where the cuticle of the berry has been destroyed, with a dark-brown border. Previous to the bursting or rupturing of the cuticle the entire spot is of a deep brown color.

These spots enlarge, retaining a more or less regular, rounded outline, and between the light-colored central portion and the dark border-line there often appears a well-defined band of bright vermilion. Finally, under the action of the disease the berries begin to wither and dry up, leaving nothing apparently but the skin and the seeds. There is no browning of the tissues of the berry, as in the case of the Black-Rot, nor does the skin shrivel, as in that disease, leaving prominent and very irregular ridges, but the circular spots first formed are easily seen and the colorings characteristic of the disease are retained, imparting a striking appearance which has given rise to the local name of "Bird's eye rot." A berry may be attacked upon one side when it is not more than half grown; it then becomes irregular in shape, the diseased part making no further development, and it sometimes happens that this side cracks open, exposing the seeds, which are gradually forced out by the unequal growth.

THE FUNGUS.

The fungus of Anthracnose (*Sphaceloma ampelinum*) doubtless belongs to the same class as that which includes the fungus of the Black-Rot, but the several stages of its development have never been satisfactorily made out. We only know it in its active or disease-producing form, the various details of which are illustrated in Plate IV. The spores of the *Sphaceloma* germinate readily in water, and if these germinating spores are sown upon the green and healthy parts of the vine the characteristic spots of Anthracnose will appear in about eight days. In often-repeated experiments the disease has shown itself at the points where the spores were sown, and nowhere else.

REMEDIES.

The *Sphaceloma* grows very near the surface, and as soon as it has burst through the epidermis it is practically exposed in all its parts to the direct action of fungicides. Much mischief to the vine may

be done before this exposure of the mycelium and spores takes place, and consequently, here as elsewhere, prevention is more valuable than cure.

Certain varieties of grapes are more subject to this disease than others, but if we attempt to avoid Anthracnose, Black-Rot, and the Mildews by a system of selection based upon this principle, we will have to discard grape culture entirely, or at least all those varieties which are most highly prized. The kinds that usually escape the Mildew are, in some cases, the very ones most "susceptible" to the Black-Rot, and those which may "resist" the latter malady may be the first to succumb to the Anthracnose.

Anthracnose is most prevalent in wet seasons and in low situations or where the vineyards are poorly drained; and too heavy manuring, especially with fresh stable manure, is said to favor its development.

Water in a condensed form is necessary for the diffusion and propagation of the fungus of Anthracnose, and any appliance that shall prevent deposition of rain or dew upon the foliage or other parts of the vine will secure immunity from the disease. Inclosing the half-grown bunches of grapes in paper bags will doubtless be as useful a protection of the berries against Anthracnose as from Black-rot, and for the same reasons. This system of vine protection, excepting for the berries, is hardly practicable in vineyards of any size, and other remedies must be sought.

In districts in Europe where the vines are subject to this disease the practice is quite general to bathe or wash the vines in early spring, before the buds have commenced to expand, with a strong solution (50 per cent.) of sulphate of iron, applied with an ordinary mop or large sponge, fixed to the end of a stick 2 or 3 feet long. This washing should be done when the atmosphere is damp, in order to prevent a too rapid evaporation of the iron solution, which otherwise might result in injury to the vine. When the young shoots have attained a length of 5 or 6 inches they receive a good dusting with the flowers of sulphur, whether the disease has appeared on them or not. The new growth is then carefully watched, and at the first sign of the malady the vines are again treated, this time with sulphur, to which has been added one-third to one-half its bulk of powdered lime. If the progress of the disease is not checked by this treatment the sulphur is omitted in subsequent applications, which are of finely pulverized lime.

Where this treatment of the vines with sulphate of iron, followed by heavy and frequent use of sulphur or sulphur and lime, has been adhered to for several years, Anthracnose now rarely appears, or has ceased to be injurious, even in locations where before it was exceedingly destructive.

From recent experiments it appears that quicker and more positive results may be obtained with the aid of sulphate of copper. To the iron solution (500 grams to the liter of water), with which the vines are bathed just before the buds begin to expand in the spring, sulphate of copper is added at the rate of 50 grams to the liter; and in the sulphurings which follow add to the sulphur one-tenth its weight in sulphate of copper, very finely powdered.

A correspondent in *La Vigne Américaine*, December, 1886, states that he treated his vines for Anthracnose, by liberally washing them with the Bordeaux mixture. This application was made during the season of growth, for the writer goes on to say that "in a short time the disease disappeared, vegetation started up again with vigor; the

clusters which still remained at the time of treatment took a normal development, and in autumn the vines were finer than they had ever been." He had often used sulphate of iron for the treatment of the same disease, but never with such a result.

It is greatly to be hoped that those having vines subject to this disease will give these remedies a thorough trial, both to determine their value and quickness of action.

Distribution and severity of the Grape Mildews and Black-Rot in the United States.

With the Circular on Remedies for Mildew and Rot, given in full on page 99, there was sent out a circular of inquiry, having for its object the obtaining of a more definite knowledge as to the distribution of, and losses occasioned by, Grape-vine Mildews and Black-Rot of the grape.

Nearly 400 of these circulars were returned filled out, in the majority of cases with evident care; and the information thus acquired forms an important chapter in my special report on the Fungus Diseases of the Grape-vine, from which I extract the following:

THE MILDEWS.

Of all who reported, 202 had neither observed nor heard of the Mildews in their county, or did not know them, or did not state. One hundred and eighty persons, in nearly as many localities, stated the presence of *Uncinula spiralis* or *Peronospora viticola*, or both, with varying degrees of injury to the vineyards. The reported loss, depending upon the locality and the season, ranges from "slight" to "total." Nearly one-third of all who reported stated the loss in the vineyards of their section to be in bad years from 25 to 50 per cent. of the crop, and in some instances, in particular vineyards or upon certain varieties, the entire crop. If the reports received can be taken as fairly indicative of the loss from Mildews throughout the grape-growing regions of the United States, then it may be positively stated that during the past ten years this has been as much as 10 or 15 per cent. annually.

Almost without exception, *Uncinula spiralis* is reported to do serious injury only in dry districts or during severe drought, and chiefly to foreign grapes and a few natives, such as the Delaware. In a few cases a loss of from 10 to 50 per cent. or more is ascribed solely to *Uncinula*. This fungus is widely distributed in the United States, ranging from Massachusetts to Georgia, and westward across the continent to the Pacific; but the losses occasioned thereby in the country as a whole appear to be trifling.

Peronospora viticola occurs in nearly all parts of the United States, on wild as well as cultivated sorts. Even the Pacific coast, which long enjoyed perfect immunity, is not now free from it. During the last year at least 8 different counties in California reported its presence, with losses on certain varities ranging from 5 to 100 per cent. It is found also in Utah, and probably occurs in Oregon. It is relatively most prevalent from the mid Atlantic coast district west to the Mississippi and southwest into Texas. This fungus everywhere injures the vineyards, often attacking fruit as well as leaves. It occurs on the vines throughout the growing season, but is usually worse from June to August. All report its growth to be favored by warm and wet weather, particularly by hot weather following pro-

tracted rains. In bad seasons all varieties, without exception, are subject to its attacks. Those esteemed as particularly hardy and free from it in one locality succumb to it in another, or even in the same locality another year. On the whole, the varieties reported most free from it are Scuppernong, Norton's Virginia, and Ives's Seedling. Almost the entire loss from Mildew must be attributed to *Peronospora viticola*, since, as above stated, *Uncinula spiralis* does serious injury only in a few restricted districts.

(For distribution and severity in United States, see map.)

THE BLACK-ROT.

Two hundred and twenty-eight persons reported the presence of Black-rot.

The territory over which *Phoma uvicola* is reported includes the chief vine-growing regions of the United States, and coincides with the Mildew district, save that no rot is reported west of the Rocky Mountains, except doubtfully in one instance, and but very little north of latitude 43°. In some districts this fungus has been under observation for more than twenty years, and in many, during the last decade, it has done serious and increasing injury. It usually attracts attention about the time the grapes are beginning to color, or a little earlier, and in very warm, wet seasons may within a week or ten days destroy the whole product of a vineyard. As in the case of *Peronospora viticola*, its growth is said to be greatly favored by warm and wet weather, and entirely stopped by a protracted drought. The Concord, Catawba, Isabella, Hartford Prolific, and Rogers-hybrid varieties seem most subject to this rot, and the Delaware and other light-colored or white varieties least; but no variety is entirely free from its attacks, unless it be the Scuppernong, which is said to be harmed by nothing. Many persons report all varieties equally subject. Often those reported "iron-clad" and "rot-proof" in one locality are said to be very badly affected in some other.

(For distribution and severity in United States, see map.)

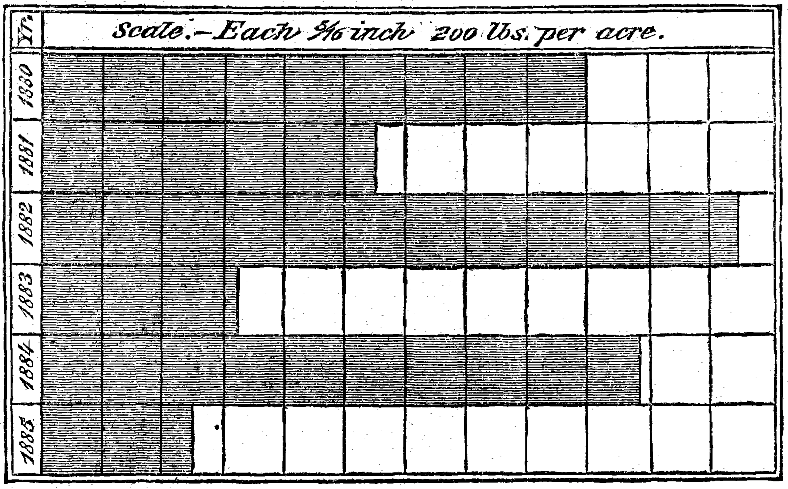
SHRINKAGE OF YIELD IN OHIO.

(See diagram.)

The enormous shrinkage of the grape crop in 1881, 1883, and 1885 was due principally to three factors which cannot be separated—Rot, Mildew, and the effect of the previous severe winter. That freezing was the factor least important may be assumed from the fact that the winter of 1883-'84 was also severe, and killed or froze back many vines, even hardy varieties, but did not prevent a good crop in 1884. In 1882 the late summer and the autumn were dry. In 1883 it was cold and wet in the spring, and there was long-continued wet weather in June and July. In the summer and early autumn of 1884 Ohio experienced one of the most widespread, prolonged, and severe droughts ever recorded. In 1885 in Northern and Central Ohio the spring was backward. June and July were warm and wet; August and the first part of September were cold and wet.

Mildew and Rot were unusually prevalent and destructive in the *wet seasons* of 1883 and 1885, taking the greater part of the crop in many vineyards. In the *dry seasons* of 1882 and 1884 there was comparatively little Rot or Mildew. The total product was 27,503,000

pounds in 1882, 6,191,072 in 1883, 20,895,563 in 1884, and 9,043,216 in 1885.



CELERY-LEAF BLIGHT.

Cercospora Apii Fries.

(Plate V.)

Celery-leaf Blight is a common disease in Europe, and one which seems to be widespread in this country, samples having been received from Louisiana, Missouri, and from about Washington. Some varieties of celery are more subject to it than others, and in seasons favorable to the development of the fungus these are greatly damaged by its attacks.

Prof. S. M. Tracy, of the State University, Columbia, Mo., has made a study of this disease in his locality, and in reply to inquiries on the subject he writes as follows:

The Celery-leaf Blight (*Cercospora Apii*), was first noticed in 1884, when it damaged the crop to a considerable extent. In 1885 it appeared again soon after the plants were put in the open ground, about July 10, or as soon as the hot dry weather commenced. The older leaves were the first to be attacked, but the disease spread rapidly, and by the middle of August many plants were dead, and others appeared as though the leaves had been scorched by intense heat. In nearly every case the Blight developed first on the driest soil. By September 1 many lots of the plants had been nearly destroyed, and all the celery grown in this part of the State was seriously injured. The loss was certainly not less than half the crop.

As soon as the rains and cool nights of September commenced the Blight disappeared, and plants which had not been too seriously weakened then made a moderate growth.

Different varieties showed a marked difference in resisting power; the "Boston Market" and "Golden Heart" suffering more than did any others, while the "White Plume" was but slightly injured. In 1886, although the season was unusually hot and dry, conditions which have heretofore seemed favorable to the development of the Blight, but very little has been seen, careful and repeated search giving only an occasional leaf which showed any injury. In the latter part of July I noticed this Blight as quite plentiful about Davenport, Iowa; also at Plattsville, Wis. Various remedies were tried, but no good results followed their use. Salt, ashes, lime, and sulphur were dusted over the leaves without effect.

Mr. T. F. Baker, a successful and well-known vegetable gardener and seed grower of Bridgeton, N. J., relates his experience with this disease as follows:

I regret to say that I am only too familiar with the appearance and effects of

the Celery-leaf Blight. The past season (summer of 1886) I cultivated two separate plats of 10,000 plants each.

(1) *After radishes.*—On this plat fifty loads of stable manure had been applied the fall previous, and in the spring fertilizers were applied at the rate of one ton per acre. After the crop the ground was again plowed and harrowed and furrows opened 6 inches deep, in which night soil (privy manure and marsh mud) was applied heavily. This was slightly covered and the celery plants set 6 inches apart in the rows, July 16. The state of the weather was so favorable that during the next month the celery made a strong and vigorous growth. So rapid was the growth that "handling" was commenced, the first operation previous to blanching. No change occurred until September 20, when, after several hot and muggy days, the small pale spots, or blotches, appeared, and these in the space of a few dsay enlarged so as to embrace the entire leaf, which consequently turned brown and appeared now to be covered with a white or powdery mildew. The stems and leaf stalks turned yellow, after which they shriveled away, and they also turned brown to black above ground, the portion under ground remaining yellow, and showing brown streaks in the cells of the stems extending to the junction of the stem and crown of the plant.

These stems and leaves were pulled off and cleared away as fast as time would permit, but the same conditions continued. Stem after stem succumbed, following in quick succession, leaving nothing but the heart of the plants. I now despaired of my crop, but about the middle of October cooler weather set in, with more rain, and the plants began to revive, and I again commenced to cultivate and to hope. The result was a fair crop at harvesting; short, though particularly crisp and tender from quick growth.

(2) *After early cabbage.*—This plot had received 25 loads of stable manure broadcast, and 100 bushels of ashes per acre the year previous, and to which 35 bushels of lime were added in the spring and all plowed under together; then there was applied, broadcast, 1 ton of fertilizer, which was harrowed in. After the crop of cabbages was removed, in July, the ground was again plowed and prepared, furrows were opened 6 inches deep and a liberal dressing of hen manure applied in the furrows. The celery plants were set July 21, and an uninterrupted growth continued until September 29, when the Blight made its first showing in the pale and brown spots and blotches on the leaves. I commenced at once to remove all such stems by pulling off and taking out of the patch. I had no further trouble from the Blight, but whether this treatment produced the result, or whether it was due to a change in atmospheric conditions, I cannot say. Plat No. 2 resisted the attack longer than No. 1, and recovered without material damage. The heart and roots do not seem to be affected by the Blight, and where the soil is strong and rich in plant food, and the weather cool and moist, the plants may possibly outgrow an early attack and mature a fair crop.

The past season was the first that I have noticed the pale spots on the leaves, or the powdery appearance upon the upper surface. I am inclined to believe from the season's experience that manure in the rows, as in Plat 1, is conducive to the development of the Blight.

The variety known as the "White Plume," was the first to be attacked, and suffered most; the "Half Dwarf" variety resisted the attack longest and suffered least. The "White Plume," however, recovered soonest from the disease, and developed the largest and fullest heart.

This disease is quite distinct from any general yellowing, or what might be properly termed "blight" of the leaves, which may arise from some injury to the roots, to the lack of proper food-elements in the soil, or from an excess of rain or drought, and is undoubtedly due to the direct action of the fungus. The result of this action is the partial or complete destruction of the leaves, which are at once the lungs and digestive organs of the plant, and it is needless to speak of the gravity of any cause which may effect injury to organs of such vital importance. The period when the fungus is most active is from early in July to the latter part of August, but I have found upon celery in the markets during the latter part of October leaves that were strongly infested with the disease.

External characters.—The first evidence of the Celery-leaf Blight is the appearance upon both sides of the leaf of pale yellowish-green spots, irregular or somewhat rounded in outline, and varying from one-sixteenth to one-fourth of an inch in diameter. These spots soon

turn brown, a central portion sometimes becoming lighter colored, and, if the disease is allowed to progress, they increase in size until the entire leaf becomes browned and dried up.

The fungus.—The fungus of the Celery-leaf Blight (*Cercospora Apii*, Fries) belongs to a genus numbering over 230 species, all of which attack the living leaves of plants, and many do serious injury in this way to our cultivated crops.

Our knowledge of these fungi is very imperfect. We only know them in their most active state, when they do the most harm by feeding upon the foliage of the plants they infest. We have, however, sufficient reasons for believing that the species now included in the genus *Cercospora* represent only a state in a metamorphosis that leads to some higher or more perfect, but as yet unknown, form; in other words, they are comparable to the larvæ of destructive insects that are only known in their larval state. In each of the stages in the development of these fungi we may presume that there are produced special spores or reproductive bodies, which serve to multiply the species, and it is very likely that if we had a complete knowledge of these forms we would find the task of remedying the evils they inflict much easier than it now is. These remarks are applicable to the species of many other recognized genera which we will have to discuss, and indicate in a brief way the line of investigations that must be made and their importance and magnitude.

The spores, or, more definitely speaking, the conidia, of the *Cercospora* in question are from 20 to 80μ* in length, straight or slightly curved, and somewhat club-shaped, being about 4μ in diameter at their thickest part; they are colorless, transparent, and are divided into from 3 to 10 cells by cross-walls or septa (See Plate V.) One of these spores falling upon a celery leaf where there is an excess of moisture will in a few hours develop one or more germ-tubes—each cell composing the spore is capable of thus germinating—which soon find their way into the interior of the leaf, probably by direct penetration of the cuticle, and there make a considerable growth in the loose tissues near the back or lower surface. This growth, which we term the vegetative growth of the fungus, destroys the contents of the cells surrounding it, turning the latter brown, and thus producing the characteristic external appearance of the disease. After a time the mycelial threads composing the vegetative part of the fungus become particularly abundant just beneath the stomata of the leaf, and through each of these it pushes outward a number of short, irregular threads or hyphæ, upon the tips of which the spores or conidia are borne (See Plate V, Fig. 2.) The hyphæ vary in length from 30 to 80μ and are between 4 and 5μ in diameter; they are usually provided with one or two septa near the base.

Remedies.—The conidia will retain their vitality some time, at least, after they have been thoroughly dried, for I have succeeded in making them germinate in pure water after they had lain in the herbarium for several months. Whether these spores will retain their vitality through the winter, when exposed out of doors, is unknown, but it is not at all likely that they will. They are doubtless designed for the immediate propagation and dissemination of the fungus; therefore any means which may succeed in preventing their formation or hinder their germination will check the disease which this develops. We may accomplish this, in part at least, by watching

***μ is the sign for micromillimeter. One μ equals .000039 of an inch.**

the leaves and removing *and destroying* all those that show any sign of infection. The fungus cannot be destroyed when it has secured a development within the tissues of the leaves without destroying the latter, and the sooner those that are diseased are removed the better. What fungicide may be found useful in preventing the germination of the spores must be determined by experiment. Any ordinary application of lime or sulphur will have little or no value for this purpose. I would hesitate to recommend the application of solutions containing the salts of copper on this vegetable for hygienic reasons. A solution of penta sulphuret of potassium, or liver of sulphur, 1 to 2 ounces to a gallon of water, sprayed upon the plants at the first appearance of the blight, may arrest its progress. This preparation deserves a trial in this case. A shelter of cloth over the plants is said to have preserved them comparatively free from blight in localities where plants not so shaded were badly diseased.

ORANGE-LEAF SCAB.

Cladosporium sp—.

(Plate VI.)

The following notes on a disease affecting the leaves of sour orange and lemon trees, which I have named Orange-leaf Scab, are essentially those read before the Botanical Club of the American Association for the Advancement of Science, at the Buffalo meeting, and published in the Bulletin of the Torrey Botanical Club for October, 1886. Since then no new light has been thrown on this obscure disease, and it is not likely that more will be discovered until it can be studied in the field.

So far as I am aware there is no published account of this disease other than that referred to above, and there is a probability that it is of recent origin; it is at least of recent appearance in Florida. The statements of correspondents and the samples which have been submitted for examination show but too plainly its serious character.

Mr. Charles W. Campbell, writing from Ocala, Fla., July 29, 1886, says that "the disease first made its appearance last summer, and seems to be increasing the present season, particularly on young trees making vigorous growth. It seems to be confined to sour stocks, although this season it has appeared on lemon trees. No sweet-orange trees have been affected, nor the sweet buds on sour stalks, even when growing side by side with trees badly affected. It is very destructive to the growth of trees and ruinous to young nursery stocks, so that fears are entertained that it will seriously affect the orange interest unless means are discovered for checking it. Last season and this have been exceedingly wet, and the appearance of the fungi may be due to this fact."

From letters received from Mr. C. F. A. Bielby, of De Land, Fla., we draw the following conclusions: (1) That the trees most severely affected with this leaf disease last season suffered during the winter more than those not affected; (2) trees affected last season are the ones first attacked this spring, although the foliage of these is entirely new growth; (3) so far as observed sour trees alone are affected; (4) location and nature of the soil or of the fertilizers used have no influence on the disease; (5) the most vigorous as well as the "sickly" trees are alike affected; (6) if a tree is diseased in part, the tendency is for the whole tree to become so; (7) the malady does not appear to spread

in the grove, but may occur at several points simultaneously. The evidence of these facts points to a fungus origin for the disease.

DESCRIPTION OF THE DISEASE.

There first appears upon either the upper or lower surface of the leaves, more particularly upon the latter and upon the young shoots, small, light-colored, wart-like excrescences. These excrescences increase in number and size, the approximate ones often running together until the whole surface is covered, destroying of course the vitality of the leaf. When young leaves are attacked they become more or less distorted and their full development is prevented. The top of the older warts, if one may so term them, are dark brown or nearly black, due to the presence of a dense fungus growth, which exhibits under the microscope a multitude of irregularly developed conidiophores, bearing oblong, oval, one-celled conidia. (See Plate VI, Fig. 3.) Such low forms as here represented are difficult to determine or classify, and it is just such forms which are often the most injurious. Further investigations in its development will doubtless reveal its true character. From what is now known it seems best to place it in the genus *Cladosporium*.

Upon some diseased specimens recently received from Ocala there was discovered a species of *Fusarium*, which Mr. J. B. Ellis,* to whom samples were submitted, believes to be identical with *F. sarcochroum*, Desm., and he expresses the opinion that the tubercles are caused by the mycelium of this fungus, these being the first outward manifestations of its growth.

It may be going too far to advance any opinion at this time, but I will say that after making many careful examinations of the samples in hand I am disposed to think that the injury in question is occasioned by the first fungus referred to above, the hyphæ and spores of which are present in greater or less abundance on all the more developed excresences.

Remedies.—The application of the following are recommended for trial as having fungicidal properties: First, a solution of bisulphide of potassium, one-half ounce to a gallon of water. Second, "liquid grison," prepared by boiling 3 pounds each of the flowers of sulphur and lime in 6 gallons of water until reduced to 2 gallons. When settled, pour off the clear liquid and bottle it for use. For use, mix one part of this clear liquid in 12 gallons of water. Third, to 10 gallons of strong soap-suds add about a pound of glycerine and one-half pint of carbolic acid.

These solutions should be applied in the form of a fine spray to the diseased trees. As intimated, what action they may have towards arresting the malady remains to be determined by experiment.

THE POTATO-ROT.

Phytophthora infestans, De By.

(Plate VII.)

There is no vegetable more widely or generally used by all classes than the potato, and any disease affecting a product of such universal importance is of interest to every one. Although there are a number

*I desire to take this occasion to acknowledge the many kind favors received from Mr. Ellis in the naming of specimens of fungi submitted to him by me.

of fungus diseases that affect the potato in one way or another, the disease most to be feared, and which has caused greater losses to this crop than all other sources of injury combined, is the Potato-rot.

There are very few farmers in the principal potato-growing States who have not suffered to some extent at least from this evil, and in seasons favorable to the development of the disease many there are who have lost one-half or even their entire crop on account of it.

This was one of the first plant diseases investigated by scientists with a view of obtaining some efficient remedy. These investigations have settled the direct cause of Potato-rot beyond question, but a practical and efficient remedy remains yet to be discovered. Individuals may have secured their crops from this disease by various practices, some of which may possess merits that will eventually bring them into general use; but however valuable these methods really are, a prejudice exists against their general adoption which would, in some degree at least, be removed if they were based on other authority. It is the purpose of this division to institute a series of experiments to prove to the public the real value, if any, of the treatments that appear to have been successful in the hands of some cultivators and to try others that may give promise of success.

With a view of learning the experience of practical men upon matters pertaining to this subject, and at the same time to ascertain, as far as possible, the actual range and the amount of the losses occasioned by the disease in question, a circular of inquiry was sent to the officers of all the agricultural and horticultural societies and granges throughout the country, as well as to many individuals supposed or known to be able to give the information desired. That nearly 2,500 replies, coming from every State and Territory, have already been received is significant of the general interest and importance attached to this subject. With the force available it is practically impossible to compile and arrange the material thus accumulated for publication in this report; but this work will be done as soon as the facilities at command will permit, and the results, together with a more complete account of the nature and habits of the fungus that produces the disease, will appear in a special bulletin of the division.

This report is limited to the following brief account of the disease, prepared by my assistant, Mr. Erwin F. Smith, who has also rendered valuable assistance in preparing other parts of this report.

Numerous fungi are found upon the potato, but *Phytophthora infestans* De Bary appears to be the most widely destructive one. Many of the others are only such as feed upon vegetable matter already in part or wholly disorganized. This seems to be the case with most of the bacteria and with all of the various molds which abound in rotting potatoes, though not more than in other decaying substances. A common ascomycetous fungus, one form of which is known as *Fusisporium solani* Mart., has been described as *parasitic*, and stated to be "sometimes equally damaging to potatoes with the *Peronospora* [*Phytophthora*] itself," but of this there is no good evidence. *Phytophthora infestans* is exclusively parasitic, though not entirely confined to the potato. The external appearance of this fungus is shown in Plate VII.

The brown or black discoloration of the tubers and the blight of the leaves have been thought by many growers to be different diseases, but they are only two phases of one disease, being due to the same fungus. During the growing season the mycelium of the *Phytophthora* may be found in the diseased stems and leaves; and, if there be

sufficient moisture in the air, the conidia or summer spores (see plate) are produced by myriads upon the diseased vines. These spores, blown about by the wind or carried by insects, birds, or other animals, find lodgment on healthy plants. Dry air soon destroys them, but in drops of dew or rain they germinate readily, so that many thousand new centers of infection may begin in the course of a single day. The sudden rot of the green tissues of the plant, so often observed when the weather is warm and wet, is due to the rapid propagation of the fungus by means of these summer-spores, although the direct breaking down of the tissues is generally accomplished by bacteria and *Ascomycetous* fungi.

Undoubtedly the mycelium of *Phytophthora* may grow down through the stalks and thus reach the tubers, but this has never been proved. The tubers are ordinarily infected by the conidia, which may be washed into the soil by rains or carried down by small animals. A wet rot of the tubers does not always follow their infection. Very often the only indications of disease are some superficial discolorations of the tuber. These brown or black spots contain the mycelium of the fungus. At first these spots are scattering and near the surface of the tuber, but during the winter they may increase in number and size as the mycelial threads penetrate farther and farther into the sound tissue. I have found the minute threads of this fungus penetrating the sound tissues for some distance (one centimeter or more) beyond the discolored parts of the tuber, and, by exposing these white and apparently sound portions to moist air for some days, have obtained conidiophores and conidia (see plate) with which I have caused the rot in other tubers previously sound. This is, however, no new experiment; others have obtained the same results. That in damp, warm cellars or pits the summer spores may be developed on the surface of infected tubers, and that the neighboring sound ones may thus be infected, is no longer a matter of speculation, but has been settled in the affirmative by observation.

The *Phytophthora* lives from year to year by means of its perennial mycelium lodged in the tuber. It is possible that the fungus is also propagated by winter spores, oöspores, but this not certain. Spores have been figured and described as the winter spores of this fungus, but the evidence cannot be accepted as conclusive. The parasite finds its way into the fields along with the planted tubers, either concealed as mycelium within their tissues or adhering to the surface of the tubers in the form of recently developed conidia accidentally lodged thereon. It has been shown that the mycelium may grow from the tuber in the growing shoots and reach the surface and fructify in this way, or may develop conidia in the soil upon the surface of the tuber, whence the spores may be brought to the surface and find their way to the leaves and stems by the aid of earth-worms and various burrowing insects. In favorable weather the propagation of the fungus by summer spores is so rapid that only a few original centers of infection are requisite in order to speedily infest a whole field or district.

Certain conditions favoring rot are beyond control of the farmer. He cannot prevent warm, wet weather; but, by planting upon dry ground and by using the greatest care in the selection of tubers for planting, he may greatly diminish the severity of the rot. No tubers having dark spots or blotches upon their surface, or which look brown or black in places when cut open, should be planted. Whether early or late sorts will rot worse depends chiefly on the character of the

season, *i. e.*, whether the rainy weather is early or late. However, other things being equal, quick-growing varieties are probably safest.

It is thought that something may be done to check the rot by the careful use of fungicides. As soon as brown or black specks begin to appear upon the vines they may be dusted with Podechard powder,* which treatment should be repeated as often as necessary.

David's powder,† a remedy which proved very useful in the vineyards of France in 1886, for the destruction of a fungus similar to the *Phytophthora*, may also prove useful in combating this fungus. It is recommended for trial.

As these remedies are only tentative, parallel strips through the field should be left untreated, that the treated and untreated strips may be compared at the close of the season. Only in this way can any definite results be reached.

PEAR BLIGHT.

A glance at the back volumes of the Annual Report of this Department will show that this subject of "Pear Blight" has frequently been discussed. Theories without number have been advanced as to the cause of this malady and numerous remedies have been recommended for trial or stated to effect a positive cure. In the report for 1854 blight is attributed to high culture, causing the tree to grow late in the fall, thereby preventing the wood from being well matured. In the report for 1851 the opinion of one writer is to the effect that "too much trimming, too much moisture, and too rich soils are some of the causes of blights in pear and apple trees." In the report for 1862 we find it stated that one form of "blight" in pear trees is induced by evaporation from the leaves at a time when the roots are unable to absorb moisture. The blight is attributed to insects in the report of 1863. In the report for 1868 we have the statement that "it is now fully established that the active agent in this disease is fungoid growth." In the report for 1872 it is affirmed that "Pear Blight is a local fungus fermentation of the genus *Torula*."

Remedies.—In the report for 1849 "Amputation of the diseased limbs far below the least appearance of disease, having care to keep the knife clean, so as not to inoculate healthy trees with the poisonous juices of diseased ones, and apply crude iron filings to and around the roots," is the recommended treatment.

In the report for 1851 it is stated that "the best and only remedy for blight of pear and apple trees is a full and unsparing use of the knife. Cut below the blight some distance; if you lose the limb you save the tree." In the report for 1870 mulching the trees is recommended to prevent blight.

Through the recent investigations of Professors Burrill and Arthur the true cause of Pear Blight has been demonstrated to be due to a bacterium. To Professor Burrill is due the honor of first having discovered the real nature of this disease, and the experiments made by Professor Arthur have not only verified those of Professor Burrill, but have been extended so as to settle the question beyond dispute. These gentlemen are now recognized authorities on this subject, and Professor Arthur was engaged to prepare a report upon it, as a part of the work of this section, which is here submitted.

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*See page 100. †See page 102.

PEAR BLIGHT.

Micrococcus amylovorus Bur.

By J. C. Arthur.

No introductory description of the disease called Pear Blight, or Fire Blight, is needed in order to distinguish it or call it to mind. For nearly a century it has been the most prolific theme for discussion by horticultural writers and speakers among the whole range of plant maladies. Horticultural societies have talked themselves weary over it, and editors of horticultural periodicals have found it necessary to put a brake on the blight writers. The Western New York Horticultural Society several years ago passed a resolution that the subject should not be discussed in its meetings unless there were new facts and additional information to be given. The acting president of the American Pomological Society once cooled the ardor of discussion on this subject by observing: "I confess I have nothing to say except what is pure speculation, and I have got tired of speculation and of hearing it on this subject."

One need not be at a loss to account for this perennial activity. The warm and repeated discussion which the subject has received is evidence in itself, and corroborates the fact that the disease is a serious evil, while the failure to reach conclusions that a majority can subscribe to shows how obscure and beyond ordinary scrutiny the cause lies, and how even to trace the external changes in the course of the disease has taxed the full powers of observation. It was with some appreciation of the intricate nature of the problem that different societies at various times offered, or talked of offering, prizes for the discovery of the cause of the disease and of a remedy. They often contented themselves, however, with the appointment of a committee from their own number, with instructions to study up the matter and report at a subsequent meeting. The accompanying map will show in a general way how wide an extent of country is affected. It has been compiled from such data as could be gleaned from horticultural journals and reports of horticultural societies.

How the cause of blight was finally discovered by Prof. T. J. Burrill, and additional verification worked out by the writer, need not be narrated here; it is much more to the point to state the results and practical deductions, and leave the steps by which they have been reached to be learned by reference to the original publications.

The cause of Pear Blight, as established by the last seven years of research, is connected with the activity of germs, and the malady belongs to the category of germ diseases, now definitely proven to occur both among animals and plants. The germs causing blight are of extreme tenuity; they are borne from place to place and from tree to tree by the atmosphere, which is never so quiet but that its movements are sufficient to keep such impalpable bodies afloat. Upon the germs finding entrance to the juices of the plant the disease is set up in a more or less virulent form.

At the present time it is very well understood by all that bacterial germs are in the greatest abundance everywhere, and we may well inquire why all trees, at least all pear trees, are not speedily exterminated. The chief safeguard from such a calamity is the fact that but one specific kind of bacteria (named *Micrococcus amylovorus* Bur.) is able to thrive in the tissues of the pear tree, and in consequence all

other bacteria, whatever may be their capacity for inciting disease in other plants or animals, are debarred and harmless so far as the pear tree is concerned. Why it is that only this one kind can successfully overcome the forces in the tree and break down its structure is not definitely known, but it is usually accepted that the acidity of the plant juices, being in general unfavorable to bacterial development, but not affecting this species, is to be accounted one reason, although it may not be the principal one.

Knowing that but one kind of germ can set up the disease, it becomes evident that its discontinuous appearance in the same locality is explainable on the same grounds that govern epidemic diseases of animals. It requires a conjunction of favorable circumstances not likely to be maintained long at a time, to permit maximum development, thus giving rise to occasional severe visitations, with intermediate years of feeble manifestation or total disappearance.

It is also found by means of inoculation tests that not all trees are susceptible to this disease, but only those embraced in the Pome family, such as the pear, apple, crab-apple, quince, hawthorn, and several other thorns, mountain ash, &c., and of these the pear is so much the greatest sufferer that the disease is usually called Pear Blight, although the descriptive term Fire Blight is also in common use.

Besides the safeguards already mentioned, each tree is shielded against the invasion of germs by a dry cuticle or bark which envelops the aerial portion, and when fully mature and unbroken proves an effective barrier. As the roots are protected from air infection by the soil, the tree in winter, under ordinary circumstances, is abundantly guarded at every point. In summer, however, the leaves, with their innumerable open stomata and tender watery tissues, would naturally be supposed to offer ample opportunity for the entrance of germs from the air, if such came in contact with them. It is a curious fact, however, that has yet received no explanation, but which is substantiated by both experiment and observation, that the blight bacteria will not grow in the leaves, whether naturally or artificially introduced; the death of the leaves on a blighting tree is brought about by want of nourishment, the supply being cut off when the conducting power of the limb on which they are seated is destroyed by the disease.

While the tree is well protected over most of its surface, there are, nevertheless, certain vulnerable points, and none more so than the inside of the flower cup. The surface at the base of the styles is moist and uncuticularized, and the germs which touch it are securely held, find no difficulty in penetrating and developing in the soft tissues of the thickened base of the flower, and by passing along the pedicel convey the disease to the twigs and branches. The short period that the flowers are open is time enough to seal the doom of many limbs, and even whole trees. The symptoms of the disease are not observable for days, or more usually weeks, and frequently the first knowledge of impending danger is seen in the blackening leaves near the flowers. If an early examination is made, the dead flowers, or flower-sets, no larger or but little larger than when they first opened some time before, will usually be sufficient evidence, if taken in connection with the time that has elapsed since flowering and with the present development of the foliage, to show that the germs passed in through this channel. We have in this fact a satisfactory explanation of the common observation of orchardists that trees are far more likely to succumb to the blight when they come into bearing than at any previous time.

Another vulnerable point for the attack of blight is at the growing tips of the branches, or at any point where there are developing buds. At such places the tissues, including the epidermis, are tender and filled with nutrient sap, while the outer surface of the organ is not yet cuticularized and rendered impervious. As the shoot ceases to elongate and approaches maturity the chances for infection become less and less. The early part of the season is consequently the most dangerous part, and allowing for the incubation period, during which the disease is inconspicuous, its strongest manifestation naturally falls in June and July. As the growth at the extremities is more vigorous or more protracted the possibilities of infection are correspondingly increased, and a "growing season" is likely therefore to be a blight season. A connection between immaturity and blight has long been suspected, but explanations of the matter have heretofore been erroneous.

Besides the two vulnerable points already mentioned, there may now and then be another, brought out by cracking or other injury of the bark, and occurring on any part of the tree, but more commonly on the trunk. Through these cracks, however minute, the germs gain access to the interior of the tree, and the disease is started. The after progress is usually slow, on account of the solidity of the tissues, and progressing about equally in all directions, forms a patch of dead bark, which becomes dry and hard, often somewhat sunken, and usually separated from the living bark by a well-defined outline or crack. Such injury is commonly known as *sun scald*, and has been specially studied by Professor Burrill, to whom we are indebted for our knowledge of its origin. The spots occur most abundantly on the southwest side of the tree, being the side which is most affected by the heat of the sun. The cracks through which the germs first gain access are the result of the drying out and contraction of the bark, and in so far the injury is due to the sun, although in no sense a "scald." Blight upon the trunks and larger limbs is also often contracted from small short spurs with a few leaves, which admit the germs at the time the spring growth is taking place.

Preventives and remedies.—Whatever form Pear Blight assumes, it is started by germs gaining access to the tree in one of the three ways described—through the flowers, the growing shoots, or injuries of the bark. No method is known or has yet suggested itself of rendering the tree insusceptible to the disease, and a direct prevention must be sought in some means of excluding the germs. There are three ways by which germicides may be applied to trees—by fumigation, by spraying, and by washing. The first method offers a possibility of at least partial success, and appears to be the only means by which one can hope to protect the flowers.

The trials made so far have been with sulphur mixed with lime, and applied as a wash to the trunks. It is claimed by careful orchardists that the odor of the sulphur can be detected for weeks after treatment, and that it has proved satisfactory in warding off the disease. Whether more thorough and extended experiments will substantiate this conclusion, or show that the supposed immunity comes from other and accidental causes, there is yet no firm basis for an opinion.

Spraying offers little more hope of success than fumigation. The inner surface of the flowers are so well protected by the stamens and other organs that the antiseptic used does no service. The growing shoots have their tenderest parts partially protected with the terminal cluster of leaves, and a fresh surface is continually forming which it

would be hopeless to expect to keep fully disinfected. An experiment tried during last season in spraying with a solution of hyposulphite of soda, applied several times during the period of expansion of the buds, gave no evidence of beneficial effects.

The application of washes cannot, of course, be made to the flowers or growing shoots, but excellent results may reasonably be expected when made to the trunks and larger branches. Sufficient study has not yet been given to the matter to say what will prove the most effective application, but linseed oil has been advocated as forming an elastic coating, and to it might be added some sulphur, and at least 1 per cent. of carbolic acid. This would seem to answer every requirement for an antiseptic, and for the exclusion of atmospheric germs from the cracks in the bark. To decrease the amount of cracking the body of the tree may be shielded from the sun's fiercest rays by a low trimmed head, or by leaning the whole tree toward the southwest, or by boards, matting, or other protection, on the sunny side of the trunks.

Among the indirect methods of fighting the disease none are more important than those which secure slow growth and early maturity of the shoots. This has been recognized from the first agitation of the subject, but until the present time there has been no unanimity of opinion as to the exact objects to be accomplished. From the preceding account it is apparent, however, that the chief aim should be (*a*) to keep the amount of tender surface of shoots at a minimum, in order to diminish the chances for the penetration of germs, and (*b*) to make the tissues as solid as possible, as the progress of the disease and the chances of its entire cessation are in inverse ratio to the succulency of the parts attacked.

The means for producing uniform growth and early maturity which have found favor from time to time are various, and their value for special cases is usually conditional. One of the most generally applicable methods is to convert the orchard into permanent meadow after the third or fourth year from setting, to be treated with an annual dressing of chemical fertilizers or a moderate application of stable manure. Experience shows that this method considerably reduces the percentage of blight while maintaining fruitfulness at nearly or quite the usual standard. The cultivation of some crop during the season, such as oats or buckwheat, is less effective. Restricting pruning as much as possible has some value. Root pruning has been warmly advocated, but is only advisable when there is strong probability of a severe attack of the disease, and is not applicable to all situations. Certain varieties, *e. g.*, Duchesse and Seckel, are less injured by the disease than others; and the selection of varieties in their relation to the disease is therefore to be borne in mind.

Of genuine remedies there are none; but as the disease is local, and spreads through the tissues slowly, it is possible, as has long been known, to effectively check its progress by amputation. The smaller limbs are to be cut off a foot or two below the lowest manifestation of the disease, and the spots on the trunk and larger limbs are to be shaved out, cutting deep enough to remove all discoloration. A careful operator will keep the knife disinfected with carbolic acid or otherwise; if this is not done the disease will be conveyed in a small percentage of instances to the freshly cut surface, necessitating a subsequent excision. The beneficial effects of this treatment are least apparent during periods of epidemic, when the tree is attacked at almost every vulnerable point. At such times

a more radical method has been found serviceable, which is to cut off the whole top to within a foot or two of the ground. It can be practiced to advantage upon trees that are as much as ten years old, or even older.

GRASS FUNGI.

The grasses are especially subject to the attacks of fungi, every part—the stem, leaves, flowers, and grain—being exposed to their ravages. They are the prey to members of nearly every order of the class of fungi, but those of the *Ustilagineæ*—the "smut"-producing species—are the most destructive of all. Ergot, produced in the flowers of many grasses valued for hay or forage, is caused by a pyrenomycetous fungus (*Claviceps purpurea*). This is the most notable among the grass fungi on account of its effect upon stock that may feed upon hay affected with it.

All these fungi that do more or less injury to our grass crop are of interest to the farmer and stock raiser, and as material can be collected and observations made they will be severally treated.

Last year Prof. William Trelease, of the Shaw School of Botany, furnished for this division a report on the "smut of timothy," which was published in the annual for 1885. This year, at my request, he has very kindly contributed an original paper on the leaf-spot disease of orchard grass.

A SPOT DISEASE OF ORCHARD GRASS.

Scolecotrichum graminis Fckl.

(Plate VIII.)

BY WILLIAM TRELEASE.

The drought at Madison, Wis., and through the West generally, was extreme in the summer of 1886. For months there was not a shower sufficiently heavy to wet the ground. Pastures parched up so as to appear completely dead. Lawns were kept green only by daily sprinkling, and even then there was no use for the lawn-mower. In the latter part of August an abundance of rain fell, enough, indeed, to bring the average for the summer up to the normal amount. Stimulated by this, and the prevalent warmth, grasses of all descriptions made a rapid growth, even the browned turf starting into vigorous vegetation.

Soon after this change, when the basal leaves of orchard grass (*Dactylis glomerata*) had reached their full length, my attention was attracted by a very abundant discoloration of this species, sometimes confined to the extremity of the leaves, sometimes extending nearly to their base. So far as my observations went nearly every stool of orchard grass was affected.

The characteristic appearance of the diseased leaves is shown in Fig. 1, Plate VIII. Elongated dark-brown or purplish-brown spots, visible on both surfaces of the leaf, appeared in greater or less profusion. Frequently, and as a rule when old, these spots were gray or whitish at the center, where they were marked by very minute black dots, barely visible to the naked eye, that occurred, in more or less regular rows, parallel to the nerves of the leaf. The tips of leaves that had been diseased for some time were dead and brown, but paler than the

spots. This discoloration proceeded downward, until ultimately many of the leaves appeared to be dead nearly to the base of the blade.

Under a slight enlargement, the black points on old spots appeared as velvety tufts of dark threads, protruding from the leaf. When enlarged sufficiently to show the epidermal cells of the leaf, they were seen to come from the stomata. As these occur in parallel lines, the regular arrangement of the dots is explained by their occurrence over the stomata.

A section through a leaf in one of the discolored spots shows that the epidermal cells are not much changed; but the parenchyma of the leaf-pulp is much altered, its cells having lost their plump form, and being consequently more separated than in the healthy leaf, while their normal green color has entirely disappeared, and yellow or brown oil-drops are more or less abundant in them.

These changes in the leaf are shown by such a section to be connected with the presence of a colorless mycelium of branched, occasionally septate threads running between the pulp-cells. Under the stomata the mycelium collects in a more compact form, as a sort of false parenchyma, the upper cells of which assume a smoky-brown color, and ultimately emerge through the stomata as a tuft of slightly wavy, more or less knotty, dark hyphæ, constituting the dark points that have been already referred to. When these tufts are small they merely crowd the stomata open to their fullest capacity, but in most cases they enlarge so as to tear the epidermis open.

The hyphæ which have emerged into the light in this way produce, as a rule, a single smoky-brown conidial spore each, which is borne at the apex. Occasionally a spore is also found at one of the knots along the side of a hypha. The spores originate as enlargements of the contracted tips of the hyphæ, and at first are globular, then obovid, and finally somewhat spindle-shaped. When partly grown they are separated from the ends of the hyphæ by thin walls, which split across when they are ripe, allowing them to fall. The center of each tuft of hyphæ is the oldest, and sheds its spores first. As the tuft enlarges new hyphæ are crowded through at its margin, so that, forming spores, others which are ripe and old hyphæ that have shed their spores, may be seen in a single section, as in Fig. 2. When fully mature the spores are typically two-celled, by a partition at or below the middle; but many of those which fall from these stalks and are apparently ripe are only one-celled.

The disease is propagated by these bodies, which germinate by emitting slender, flexuous, or contorted colorless mycelial threads (Fig. 2 A.) These make their way through the stomata of the grass leaf and develop between the leaf cells, forming the mycelium that is seen in section of diseased leaves, which nourishes itself at the expense of the cells it grows between, and which are ultimately destroyed.

The appearance of many of the older diseased leaves suggested that the fungus may have first attacked the dead tips of the short leaves parched by the drought. That it also causes the disease of otherwise fresh and healthy leaves is shown by the occurrence of the characteristic dark spots, bearing tufts of fertile hyphæ on green parts of these leaves, and on younger leaves that were only partly developed and entirely uninjured, except for the fungus.

The parasite which caused this spot disease of orchard-grass is *Scolecotrichum graminis*, a species which occurs on various grasses in Europe, and has been collected once or twice in this country. It is one of the so-called imperfect fungi, and may be only a form of

one of the graminicolous *Pyrenomycetes*. Fuckel* considers it to be the conidial state of *Sphaeria recutita*, but I do not know that this has been proved. At any rate, it is not improbable that it passes the winter in some such form, but its summer propagation is effected by the conidial spores that I have described.

ADDITIONAL NOTE ON ANTHRACNOSE.

(*Sphaceloma Ampelinum*, De By.)

Since the report on this subject was in type the following note has been received from Mr. G. Onderdonk, of Nursery, Tex. After referring to the statement of Mr. A. W. Pearson, in Bulletin No. 2 of this Division, to the effect that he had seen no appearance of *Sphaceloma ampelinum* on any of the Æstivalis class and that it was mostly observed on white grapes, Mr. Onderdonk says:

> The first that I ever saw of this fungus was about the year 1867. This was in this county, Victoria, Texas. A few berries of Catawba were affected. Soon after it developed freely on some Lenoir clusters, and in 1884 I knew a vineyard in which a very promising crop of Lenoir was entirely destroyed by it. The Herbemont of the same vineyard was entirely exempt. Sometimes for years we saw nothing of the work of this fungus on any variety of the grape, and then there is a sudden inroad upon some neighborhood. But the scourge has never become widespread.
>
> There is one important contrast between our experience and that of observers in New Jersey. In New Jersey none but white varieties suffered seriously, while in Southern Texas none of the white varieties became affected at all, and the variety that suffered most was the darkest color in our lot of grapes. This leads to a suggestion that there is some condition besides color that governs in the case. Perhaps a microscopic examination may reveal that the structure of the skins of some varieties is more favorable to the propagation of the fungus than in case of other varieties.

TABULAR LOCAL REPORTS.

Prof. J. C. Arthur, botanist of the New York Agricultural-Experiment Station at Geneva, was engaged to prepare a brief report on the condition of certain crops in his vicinity in respect to the principal fungous diseases affecting them. At my suggestion he reduced his observations to a tabular form, as given below. A similar table for the vicinity of Washington, and another for certain points in Michigan, are added.

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*Symbolæ, Myc., 107.

Plant diseases. Observed at Geneva, Western New York, by J. C. Arthur.

Host.	Parasite causing disease.	Name of disease.	Part affected.	Prevalence in 1886.	Occurrence and injury in other years.
Pear	Micrococcus amylovorus, Burr.	Pear blight; fire blight.	Trunk and branches	Some orchard and many nursery trees killed.	Often very destructive, killing orchards.
Apple and quince.	do	Twig blight	Small branches	But little seen	Only occasionally does permanent harm.
Pear and apple.	do	Sun scald	Trunk and large branches.	Not seen	Does little injury.
Pear	Fusicladium pyrinum, Fckl	Scab	Fruit	Less abundant than usual	May decrease the market value of some varieties fully 10 per cent.
Do	do	do	Leaves	do	Interferes with full growth.
Apple	Fusicladium dentriticum, Fckl	do	Fruit	Not as much as usual	Injures the appearance and sale of a large part of the fruit grown.
Do	do	do	Leaves	do	Does harm by retarding growth.
Pear	Morthiera Mespili, Fckl		Leaves and small branches of young trees.	Usual amount	Especially injurious to nursery stock by checking growth and making it bark-bound, so that it is necessary to import stock from France for grafting.
Quince	Morthiera Mespili, Fckl., var	Spotting	Leaves and fruit	Foliage and fruit much injured.	Usually occurs, but is not always a serious evil.
Peach		Yellows	Whole tree	Not seen	Not common in this vicinity.
Do	Exoascus deformans, Fckl	Curl	Leaves	Abundant	An unmanageable disease, that debilitates many trees and kills some.
Tomato		Black-rot	Green fruit	Did not occur	Usually common, and may destroy half the fruit.
Oats	Ustilago segetum, Pers.	Smut	Whole plant		Inconspicuous, but usually destroys fully 10 per cent. of the crop.
Corn	Ustilago Zeæ-Mays (D. C.)	do	do	Common	Common.
Cereals	Puccinia (several species)	Rust	do	do	Do.
Plum and cherry.	Septoria cerasina, Pk	Cherry-leaf spot	Leaves, causing premature fall of.	Abundant on young trees	Common and a specially serious drain on the vigor of young trees.
Clematis		Rot	Roots	Usual abundance	Kills the plant attacked, and is common both out of doors and in propagating-houses.

Partial list of parasitic diseases of cultivated plants observed in Michigan by Erwin F. Smith.

[Observations chiefly in Ionia, Clinton, Ingham, and Washtenaw Counties.]

Host.	Fungus causing the disease.	Common name.	Parts affected.	Observed in 1886.		Remarks on prevalence, severity, &c., in previous years.
				Locality.	Severity.	
Pear	Micrococcus amylovorus, Burr.	Blight	Trunk and branches	Lansing	Sporadic. Severe on trees attacked, destroying large fruit-bearing limbs.	Not very destructive in the counties named. Many orchards entirely free.
Apple	......do	Twig-blight	Smaller branches	Not observed		Some years ago an orchard near Lansing was severely injured for several years in succession, but in 1886 I could find no trace of the disease in it, and the trees seemed to have recovered.
Wheat	Puccinia graminis, Pers.	Rust	All green parts, especially leaves and stems.	Ann Arbor	Moderately plentiful	On low ground, or late sowings, the loss frequently reaches 50 per cent. I have seen 20-acre fields so badly infested that clouds of red spore-dust followed the reaper, and covered the clothing and bodies of the workmen. In such cases the wheat is always badly shrunken.
Blackberry	Cæoma nitens, Schw	....do	Green parts	....do	Serious injury to leaves and canes.	Common most years on both wild and cultivated sorts.
Corn	Ustilago Zeæ-Mays, Wint.	Smut	Green parts, especially flowers and fruits.	Not observed		Common and destructive. Most farmers take its presence as a matter of course.
Oats	Ustilago segetum, Pers.	....do	Flowers and fruit	....do		Common and destructive.
Wheat	......do	....do	....do	....do		Does more or less injury every year. I saw one field of 5 acres much injured (50 per cent.) in 1870.
Grape	Uncinula spiralis, B. & C.	Powdery mildew.	Green parts	Not observed		Occurs generally, but rarely does any serious injury.
Virginia creeper.	Uncinula subfusca, B. & C.	....do	....do	Ann Arbor, Detroit.	Foliage considerably injured.	
Wheat	Erysiphe graminis, D. C.	Wheat mildew	Leaves and culms	Ann Arbor	In one field only; confined chiefly to the lower leaves.	Common every year on June grass.
Plum	Plowrightia morbosa, Sacc.	Black-knot	Branches	Lansing	Not abundant	Occurs also on cherries, and I have occasionally seen it on wild plums and cherries in thickets. Not as destructive as in the East.
Grape	Physalospora Bidwellii, Sacc.	Black-rot	Fruit	Not observed; season very dry.		Common in 1885, and in all wet seasons, when the loss around Detroit and Ann Arbor is nearly or quite one-third. In some vineyards 75 per cent. of the grapes have rotted in particularly bad years.
Do	Sphaceloma ampelinum, De By.	Anthracnose	....do	Agricultural College, near Lansing.	On full-grown Amber grapes, not common.	Not elsewhere observed.
Strawberry	Ramularia Tulasnei, Sacc.	Spot disease	Leaves	Ann Arbor, Lansing, Hubbardston.	Injurious	Widely distributed, and often a serious drain upon the plant.

Partial list of parasitic diseases of cultivated plants observed in Michigan—Continued.

Host.	Fungus causing the disease.	Common name.	Parts affected.	Observed in 1886.		Remarks on prevalence, severity, &c., in previous years.
				Locality.	Severity.	
Apple	Fusicladium dentriticum, Fuck.	Scab..........	Leaves and fruit....	Ann Arbor, Lansing, Hubbardston.	Common	Widely distributed. Occasionally stops growth of apples and causes them to become one-sided or crack open. Injures the appearance and sale of fruit.
Pear.......	Fusicladium pyrinum, Fuck.	....do	....do	Ann Arbor, Lansing.	On leaves slight; on fruit severe.	Many of the pears brought into market, especially Bartletts, are much injured.
Plum	Monilia fructigena, Pers.	Rot..........	Green and ripe fruit	Lansing	Three-fourths crop on some trees—Lombards.	Causes serious loss to plum-growers. The rot spreads through clusters by contact. Tufts of ash-gray hyphæ burst through the epidermis, and bear great numbers of oval spores, which, in every instance, cause a rapid rot, when introduced in very small numbers, under the skin of sound plums, or peaches, pears, and apples. Similar punctures, without introduction of spores, in no case produced rot.
Apple and pear.	......do (?)	....do	Fruit (on tree)......	....do	Serious on one or two varieties of each.	
Peach	Exoascus deformans, Fuck.	Curl	Leaves	Ann Arbor........	Severe in one orchard. Leaves pale, and much swollen and distorted.	Observed in only a few localities.
Plum	Exoascus pruni, Fuck ..	Plum-bladders	Green fruit	Not observed	....	Occurs on fruit of *Prunus Americana* and *P. Virginiana*, wild and in cultivation, in Clinton County.
Peach	(?)	Yellows	Whole tree	...do	....	Does not occur at Lansing or Ann Arbor, but has destroyed whole orchards in the southwestern part of the State, where peach-growing is an important industry.
Tomato....	(?)	Rot..........	Green and ripening fruit.	Ann Arbor, Detroit, Ionia, Lansing, Hubbardston.	Common. Loss 25 to 50 per cent. of whole crop.	Has attracted attention in Michigan for four or five years. In 1886 the rot was worse in early part of season, but many rotten fruits were to be seen in September. The rotten spots contained bacteria and mycelia and on the surface in great numbers of the microconidia of Hypomyces Solani, also a Cladosporium resembling C. herbarum—these fungi separately and also growing together.
Beans	Glæosporium lindemuthianum, Sacc. and Mag.	Rust spots	Pods...............	Hubbardston	Infrequent	Produces round or elongate reddish-brown depressions, which deepen and coalesce, destroying the pod.
Radish	Cystopus candidus, Lev.	White rust....	Green parts	Ann Arbor	Flowers and fruit enormously enlarged and distorted.	Common everywhere on Shepherd's-purse; less so on radish and mustard.
Grape	Peronospora viticola, De By.	Downy mildew	Leaves, young stems, and fruit.	Not observed; very dry season.	....	Common about Ann Arbor, Lansing, &c., in 1885, and for some years previous. Moderately destructive.

Tabular list of some of the fungus diseases of plants observed about Washington, D. C., in 1886.

Host.	Fungus causing disease.	Common name.	Part affected.	Remarks on severity, prevalence, &c.
Pear	Micrococcus amylovorus, Bur	Blight	Trunk and branches	Severe; some orchards practically destroyed.
Apple	do	Twig-blight	Smaller branches	Very destructive in some orchards.
Do	Roestelia penicillata, Fr	Apple-rust	Leaves and fruit	Common and very severe on some varieties.
Do	Fusicladium dentriticum, Fckl	Apple-scab	Leaves, young twigs, and fruit	Not seen, except on fruit in market. Communicated by several correspondents, and reported to be very injurious. Occurs on fruit of cultivated *Crœtegus Pyracanthi*.
Peach	(?)	Yellows	Whole tree	Not uncommon.
Do	Exoascus deformans, Berk	Peach-leaf curl	Leaves	Observed, but apparently not common.
Do	Monilia sp	Rot	Green and ripe fruit	Noticed occasionally, and perhaps common.
Plum	Monilia fructigena, Pers	do	do	Common, doing considerable injury.
Do	Plowrightia morbosa, Sacc	Black-knot	Branches	Observed within the city limits; apparently not common.
Grape	Peronospora viticola, De By	Downy mildew	Leaves, green shoots, and berries	Abundant and destructive.
Do	Uncinula spiralis, B. & C	Powdery mildew	do	Common, both in the grapery and on vines out of doors.
Do	Physalospora Bidwellii, Sacc	Black-rot	Berries	Very destructive in all vineyards.
Do	Phyllosticta Labruscæ, Thum	Leaf-spot	Leaves	Common early in the season on many varieties.
Currant		Leaf-blight	do	Common on bushes on Department grounds.
Raspberry	Cylindrosporium	do	do	Do.
Strawberry	Ramularia Tulasnei, Sacc	Leaf-blight, "rust"	do	Common and destructive to some varieties.
Beet	Cercospora Betæcola, Sacc	Leaf-blight	do	Seen frequently.
Rose	Asteroma Rosæ, D. C	Rose asteroma, or "black-spot."	do	Common on several varieties in the gardens, and very destructive to the foliage.
Do	Sphærotheca pannosa, Lev	Rose mildew	do	Seen on some varieties.
Indian corn	Ustilago Zeæ-Mays (D. C.)	Smut	Various parts, especially the ear	Common, especially on the "sweet" varieties.
Oats	Ustilago segetum, Pers	do	Grain and panicle	Common.
Do	Puccinia graminis, Pers	Rust, "mildew"?	Stem and leaves	Do.
Horse chestnut	Phyllosticta sphæropsoidea, E. & E	Leaf browning	Leaves	Common and greatly injuring the foliage of the trees in the city.
Catalpa	Phyllosticta Catalpæ, E. & M	Leaf-spot	do	Common and destructive to foliage in August and September.
Elm	Sphæria Ulmæ, Schw	Elm sphæria	do	Common, injuring the foliage.
Tomato	(?)	Rot, or black-rot	Green and ripening fruit	

F. LAMSON SCRIBNER.

HON. NORMAN J. COLMAN, *Commissioner*

EXPLANATION TO PLATE I.

THE DOWNY MILDEW OF THE GRAPE, CONIDIA, CONIDIOPHORES, ETC.

FIG. 1. A conidium, or "summer spore."
FIG. 2. A similar conidium, in which the contents has commenced segmentation or division into zoöspores.
FIG. 3. A similar spore, representing a more advanced stage in the segmentation
FIG. 4. Zoöspores escaping from the conidium.
FIG. 5. A zoöspore more highly magnified, showing the two cilia.
FIG. 6. Same as Fig. 5, having lost its cilia and assumed a definite shape.
FIGS. 7 and 8. The same, pushing out germ tube.
FIG. 9. The shaded portion reprensets a fragment of mycelium of the Mildew growing between the cells of the host plant. *a*, *a*, suckers or haustoria (after Farlow).
FIG. 10. A group of fructiferous filaments or conidiophores, which have grown out of the leaf through one of the "breathing pores" (after Cornu).
FIG. 11. Fecundation of the oöspore from a sample found in the tissue of a mildewed leaf. *a*, the antheridium when about to emit its protoplasm into the oögonium (after Viala).
FIG. 12. An oöspore, or "winter spore" (after Cornu).

EXPLANATION TO PLATE II.

CONIDIA, ASCUS-FRUIT, ETC., OF UNCINULA SPIRALIS, B. AND C.

FIG. 1. Mycelium from surface of grape leaf, showing two haustoria and three upright conidiophores in different stages of growth. At the right above are two mature conidia, one of which is represented as just detached from its support.
FIG. 2. A germinating conidium, or summer spore. The spore may give rise to one or several germ tubes. These spores serve for the propagation of the fungus through the summer and autumn.
FIG. 3. Epidermis of grape-berry upon which the mycelium of *Uncinula* has grown. Much enlarged; to the unaided eye the effects of the mycelium on the berry are visible as brown lines, dots, or blotches.
FIG. 4. Perithecium, or ascus-fruit, showing pseudoparenchymatous structure; the coiled arms, or appendages; and three escaping asci with the inclosed spores—winter spores, thecaospores, or ascospores, as they are variously called. The normal number of spores is six. The conidia occur throughout the season; the perithecia are formed in autumn.

EXPLANATION TO PLATE III.

VARIOUS STAGES IN THE DEVELOPMENT OF PHYSALOSPORA BIDWELLII, SACC.

FIG. 1. A fragment of epidermis of a diseased berry, showing five of the black pustules formed by the development of the pycnidia. From four of these, slender, contorted, worm-like filaments are being extruded; these are the stylospores held together by a kind of mucilage.
FIG. 2. A section through a bit of the berry, including an immature pycnidium (P) and spermagonium (S). At O is the osteolum of the pycnidium, through which the spores escape at maturity. *m m* are dark-brown, septate mycelial threads from the conceptacles.
FIG. 3. A section of a portion of a pycnidium, more highly magnified, showing the basidia, or the stalks upon which the stylospores are borne, and several detached spores.
FIG. 4. Section through the exterior portion of a pycnidium, showing conidiophores and conidia growing from the surface.
FIG. 5. Three stylospores germinating.
FIG. 6. A section through the perithecium or conceptacle of the ascosporous form, showing the asci, &c.
FIG. 7. Two separate asci, showing the eight sporidia in each.
FIG. 8. An ascus, inclosing eight sporidia, found June 2, 1886, in grape (destroyed in 1885 by Black-Rot) kept for a week in moist air. From camera-lucida sketch made by Erwin F. Smith in the laboratory of the University of Michigan. Mr. Smith notes that the "receptacles containing the asci are numerous, and the asci themselves abundant."
FIG. 9. Four of the sporidia that have escaped from an ascus.

EXPLANATION TO PLATE IV.

THE ANTHRACNOSE OF THE GRAPE (SPHACELOMA AMPELINUM, DE BARY).

FIG. 1. A bunch of Elvira grapes partially destroyed by anthracnose. Received from G. Wanner, Walhalla, S. C., June, 1886.

FIG. 2. Vertical section (enlarged) of diseased berry, showing epidermis and subepidermal tissue. The basidia develop large numbers of spores (conidia), which lie immediately beneath the epidermis, *a*, and finally rupture the latter and escape, *b*.

FIG. 3. Section similar to *b* of Fig. 2, but more enlarged. Here we have a mass of basidia differentiated into spores, and resting upon a bright-colored stroma, *b*, beneath which *e* is a dark layer of diseased tissues, which gradually passes into the deeper sound tissue, *d*. The ruptured epidermis is seen at *a*.

FIG. 4. Mature spores, much magnified. These are usually thin walled and transparent, with one or more bright spots.

FIG. 5. Same as Fig. 4, but germinating. This fungus probably exists in other forms, yet unknown. De Bary has found spermagonia associated with Sphaceloma, but has not been able to determine whether they belong to it.

EXPLANATION TO PLATE V.

CONIDIA, CONIDIOPHORES, AND INTERNAL MYCELIUM OF CERCOSPORA APII, FRIES.

FIG. 1. The usual appearance of a leaflet of celery when attacked by blight.

FIG. 2. A much-magnified transverse section of leaflet, showing mycelium traversing the loose tissue to pass through a stoma on the lower surface and develop linear, clavate, septate, colorless conidia.

FIG. 3. A group of conidiophores pushing out of a stoma, as in Fig. 2, but more enlarged; conidia attached and separated.

FIG. 4. Another and older group of conidiophores with conidia.

FIG. 5. Germinating conidia.

FIG. 6. Internal, transparent, branching, septate mycelium.

FIG. 7. A new growth from a conidiophore (two months dry in herbarium) after soaking twelve hours in water. The infected leaves were brought in from the market in October, and this drawing was made in December

EXPLANATION TO PLATE VI.

THE ORANGE-LEAF SCAB—CLADOSPORIUM SP.

FIG. 1. Diseased leaves and twig. Received from Ocala, Fla., June, 1886.

FIG. 2. Small portion of a leaf, considerably magnified to show the wart-like excrescences in various stages of growth.

FIG. 3. A vertical section through one of the older excrescences, showing stroma, conidiophores, and conidia—of the fungus growing upon it.

EXPLANATION TO PLATE VII.

CONIDIOPHORES AND CONIDIA OF PHYTOPHTHORA INFESTANS, DE BARY.

FIG. 1. A luxuriant hypha filled with granular protoplasm, and bearing four immature conidia. The entire hypha, a considerable portion of which is not here represented, consisted of a single cell. Camera sketch, February 5, 1886. The specimen was grown from sowings of conidia made in moist air one week previous on the cut surface of a sound potato. At a later stage of growth the conidia are partitioned off by cross-walls, and the protoplasm largely disappears from the branches. In old conidiophores, at irregular intervals a few cross-walls are occasionally to be found. No septa were observed in the internal mycelium.

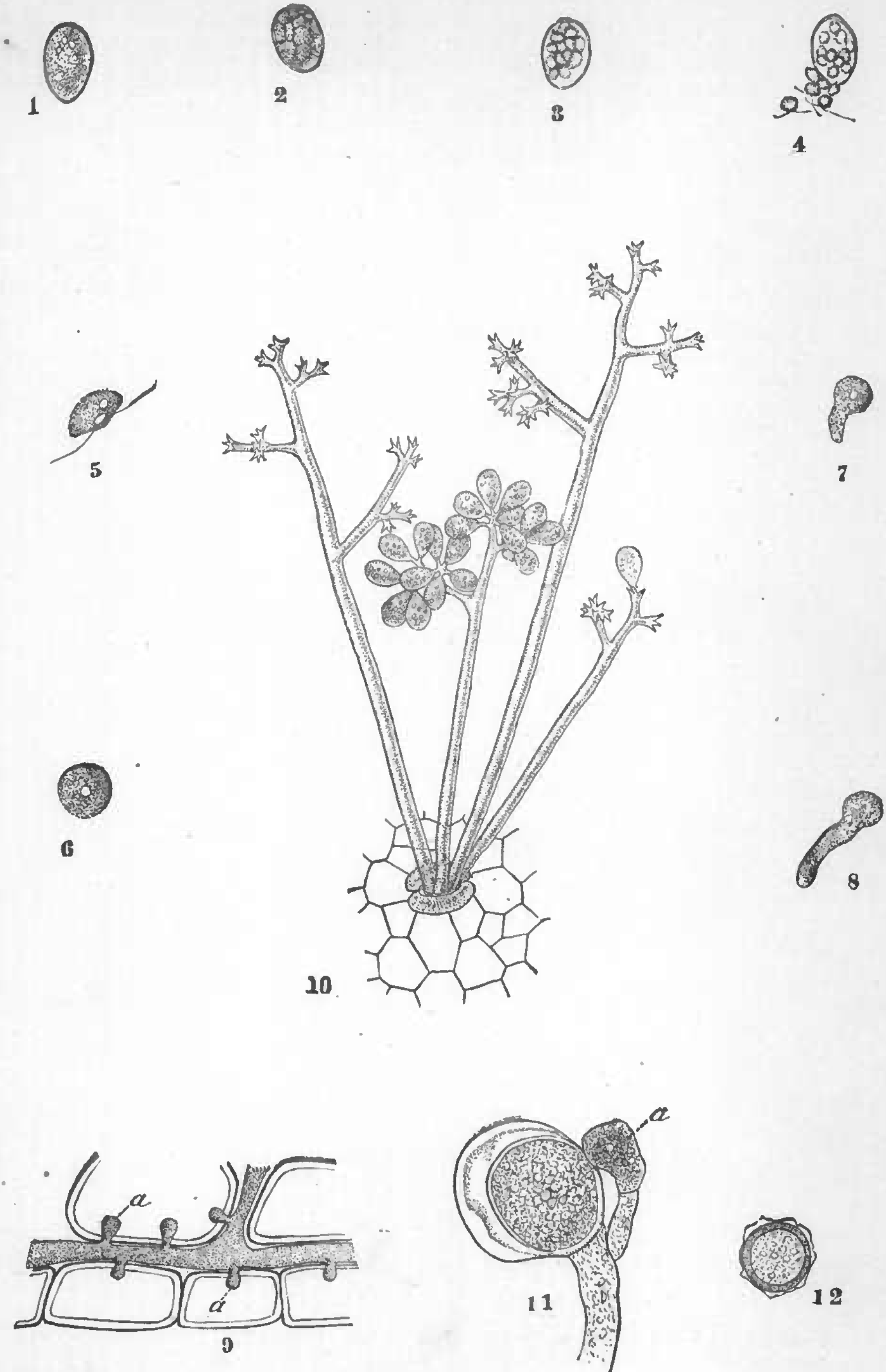
FIG. 2. A conidiophore with mature conidia in place. The spores fall off easily when mature, especially if in contact with water. This conidiophore grew from a solid white portion which was cut from the interior of a diseased tuber (one somewhat brown-spotted only), and placed in moist air, the mycelium having been previously detected in this part of the tuber. The figure shows the characteristic flask-shaped swellings of the conidiophores and the manner of attachment of the conidia. The specimen was examined dry, with a low power. The figure has been enlarged from a camera sketch, December 16, 1885.

FIG. 3. Conidiophore and ripe conidia from a growth on the cut surface of a tuber. Three conidia have fallen off at points indicated by the flask-shaped swellings. The conidia vary somewhat in size, as shown. The one still attached shows by comparison the average size. Examined in water. Camera sketch, December 4, 1885.

EXPLANATION TO PLATE VIII.

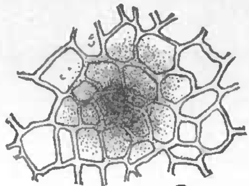
SPOT DISEASE OF ORCHARD GRASS.

FIG. 1. A portion of a leaf of *Dactylis glomerata*, showing the characteristic spots, of the disease.
FIG. 2. A section through the leaf at one of the spots, showing the fungus causing the disease.
FIG. 2 A. Spores of the fungus, germinating.



F. L. S., *del*

DOWNY MILDEW OF THE GRAPE (*Peronospora viticola*, B. & C.).



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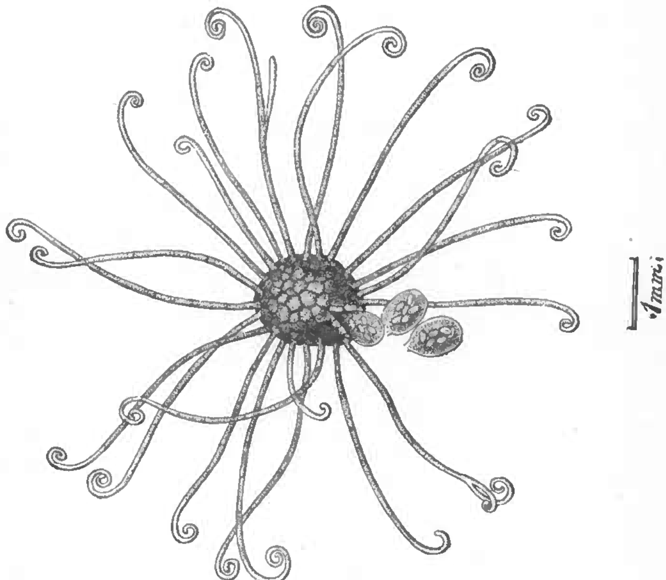

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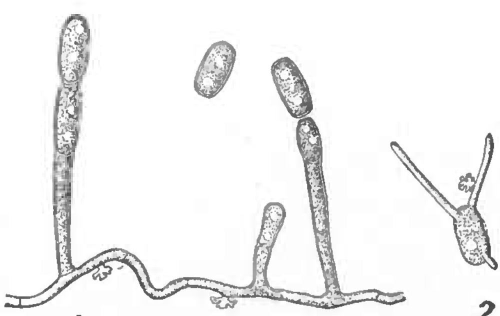

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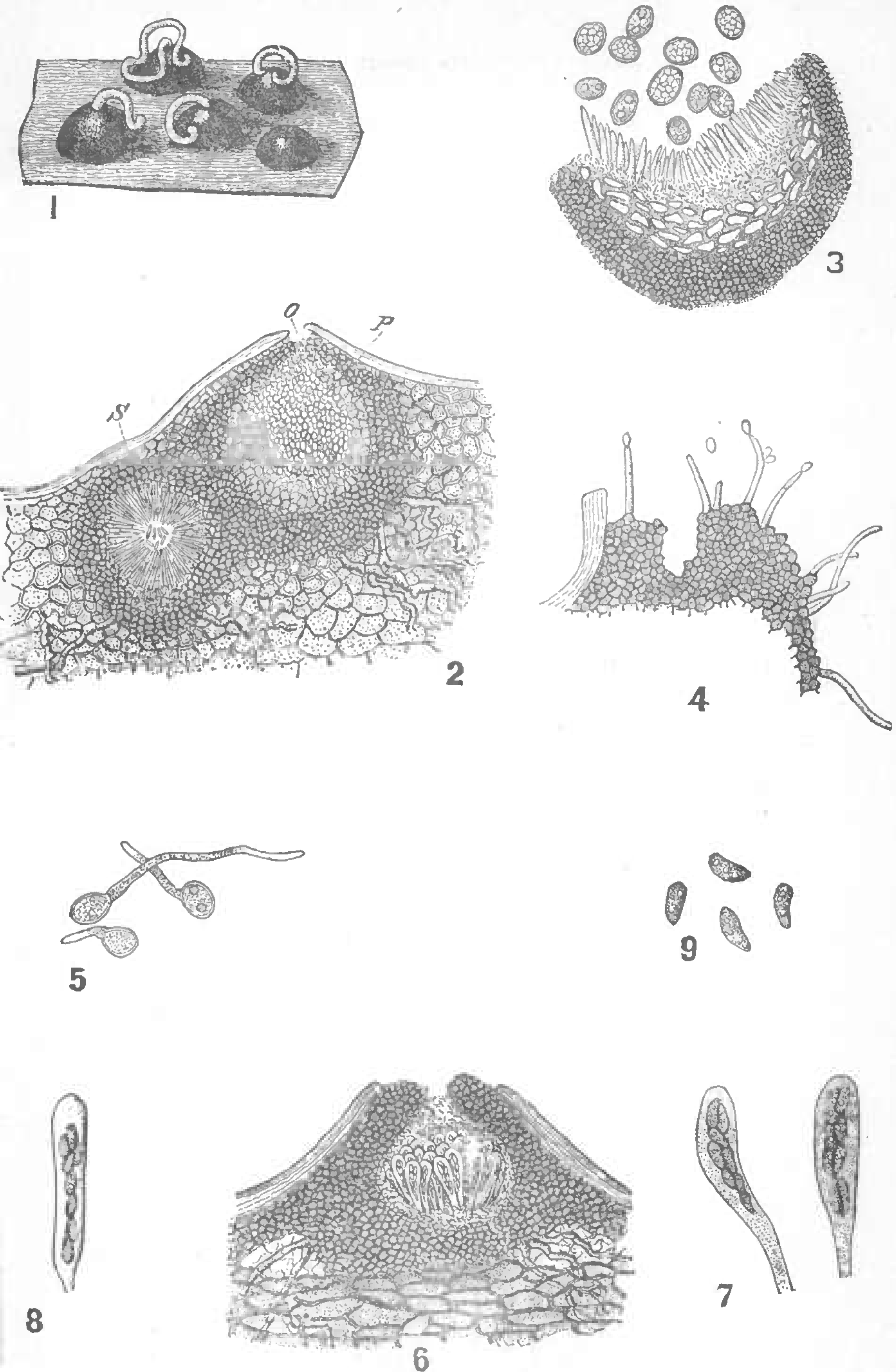
50μ.

F. L. S., *del.*

POWDERY MILDEW OF GRAPES (*Uncinula spiralis* B & C).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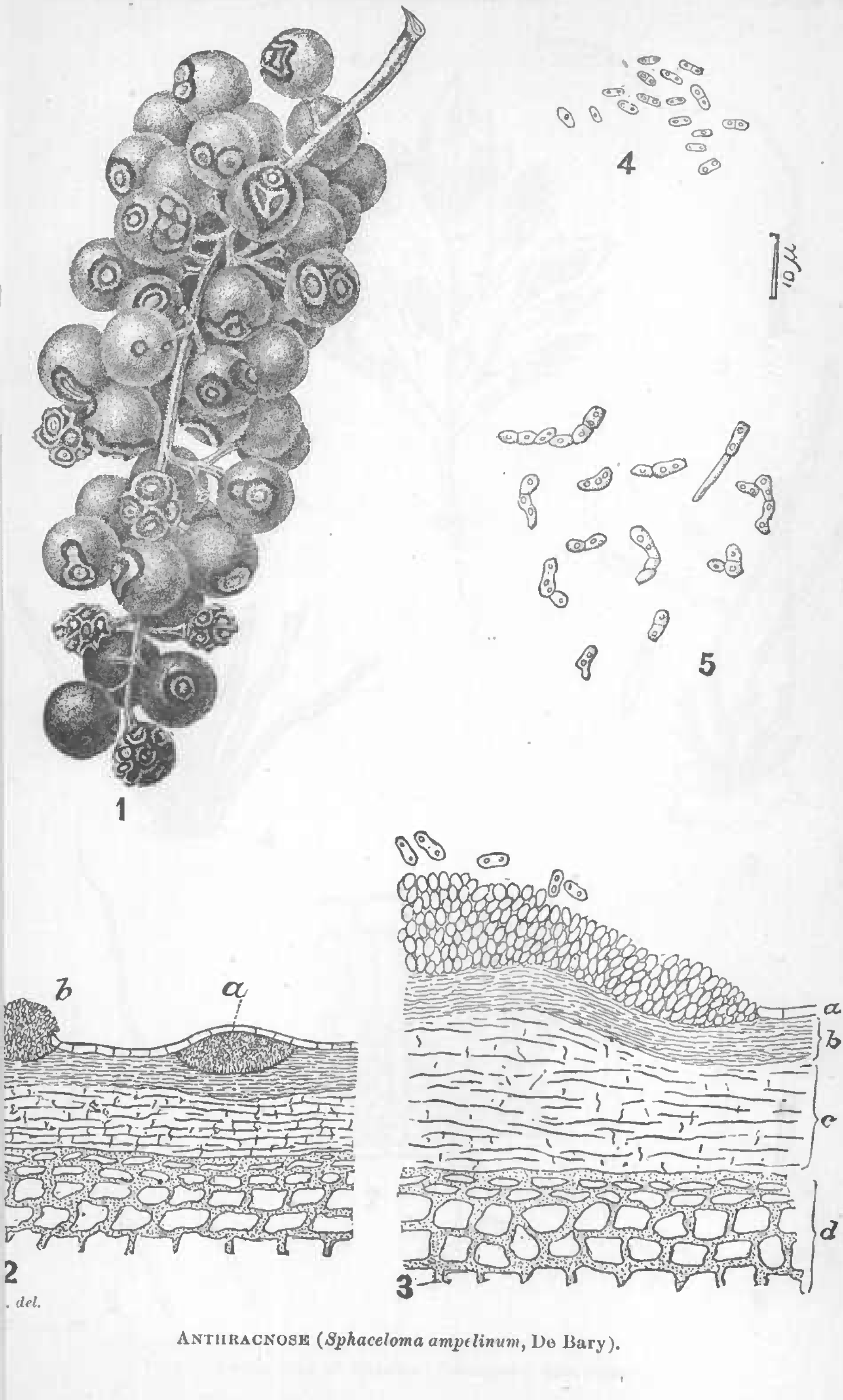
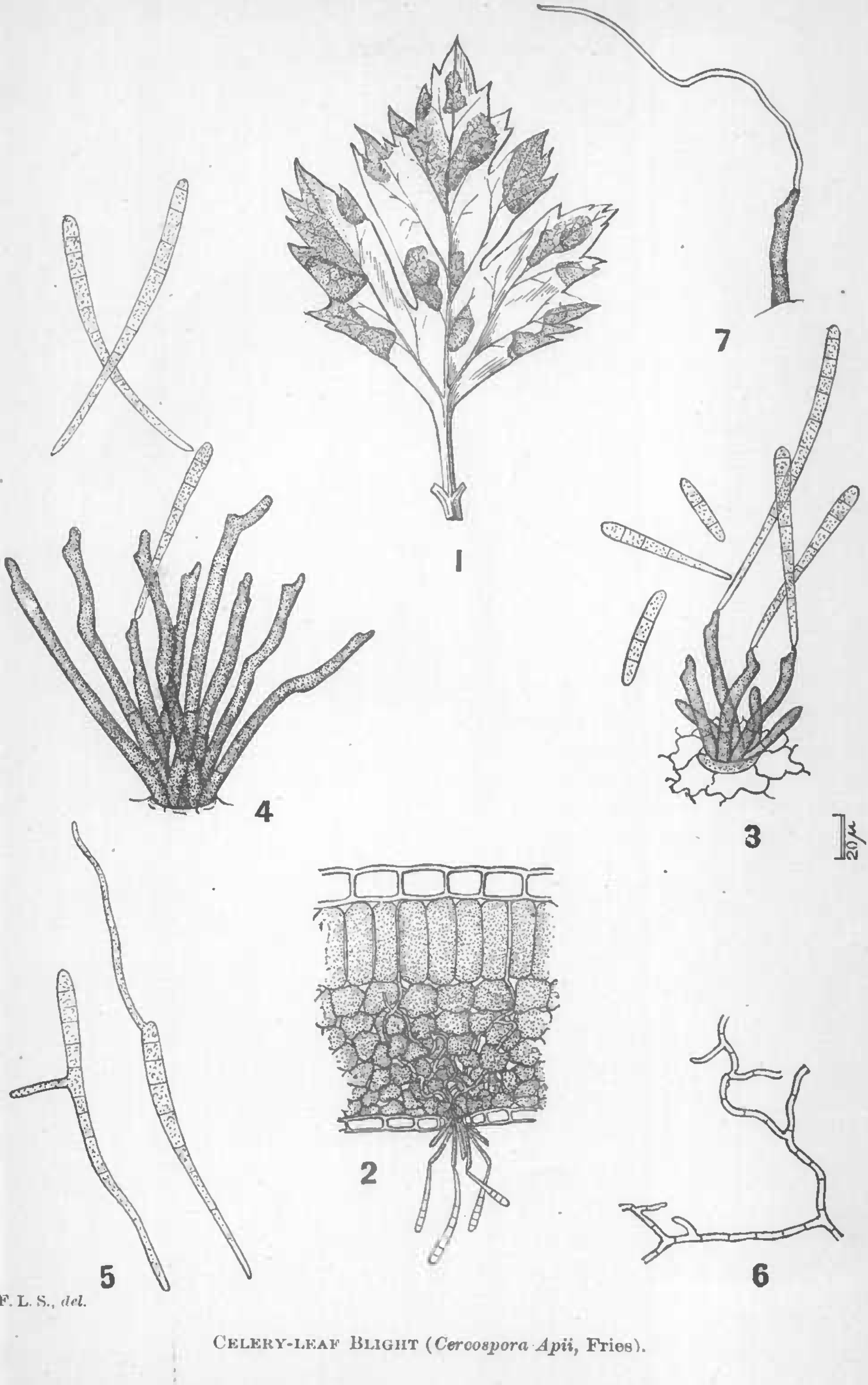


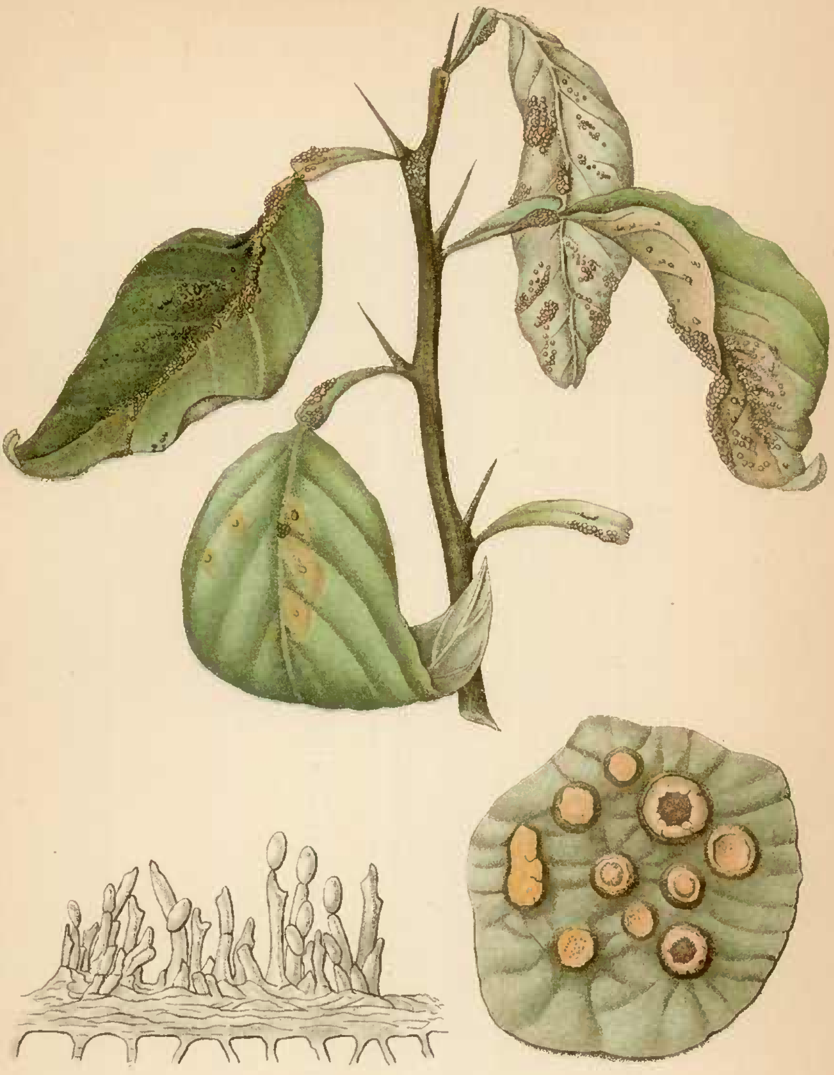
. del.

ANTHRACNOSE (*Sphaceloma ampelinum*, De Bary).



F. L. S., *del.*

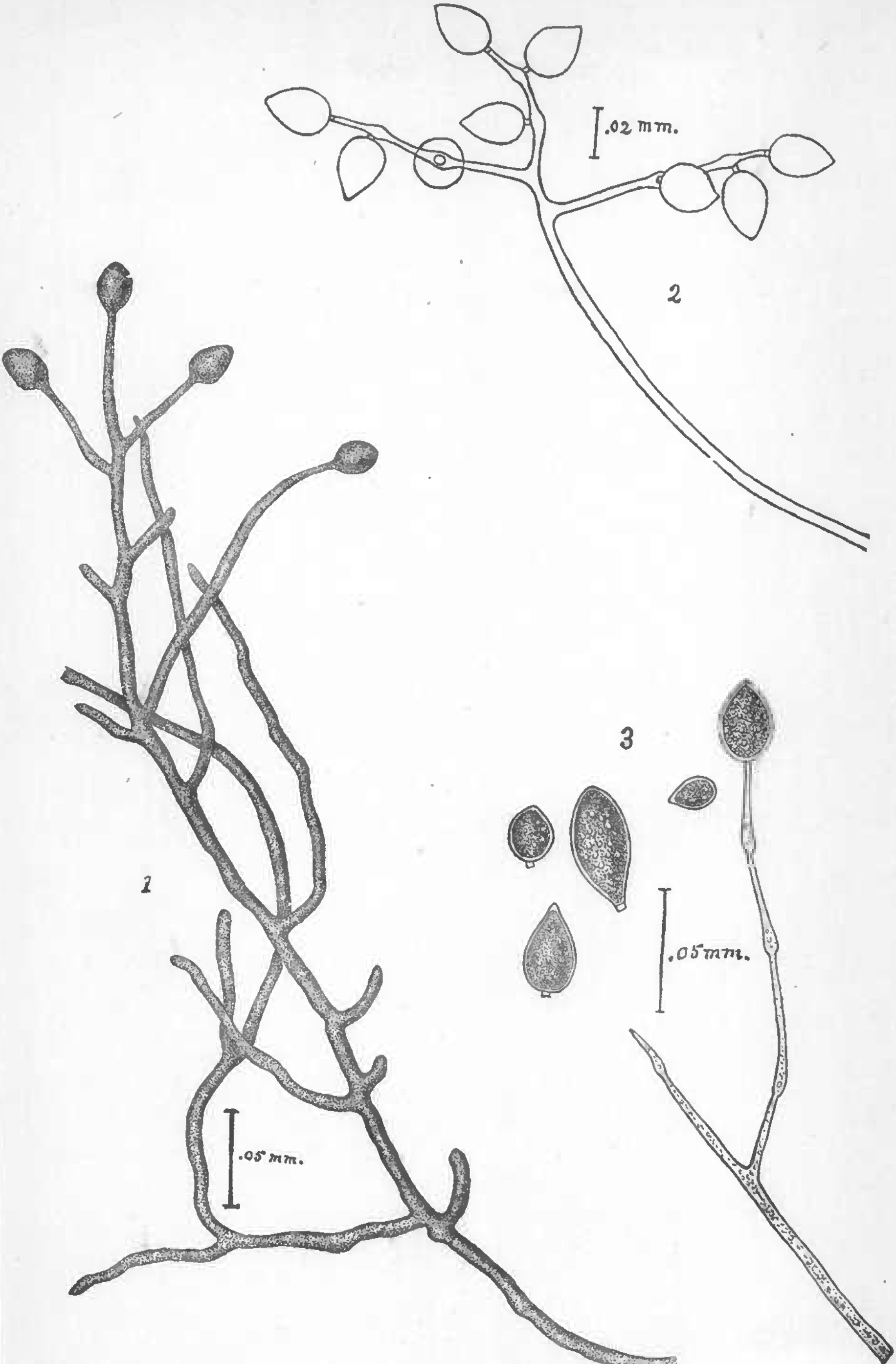
CELERY-LEAF BLIGHT (*Cercospora Apii*, Fries).



GILES LITHO. & LIBERTY PRINTING CO. N.Y.

ORANGE-LEAF SCAB

(Cladosporium sp.)



E. F. S., del.

FUNGUS OF THE POTATO ROT (*Phytophthora infestans*, De Bary).

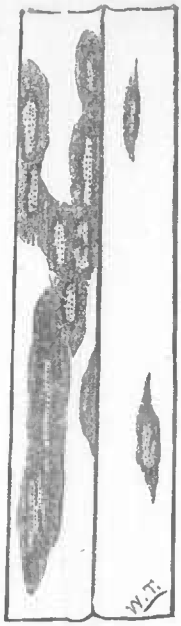


Fig. 1.

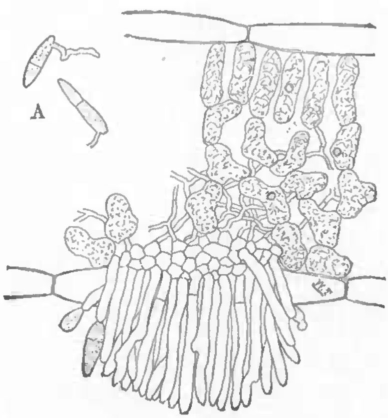
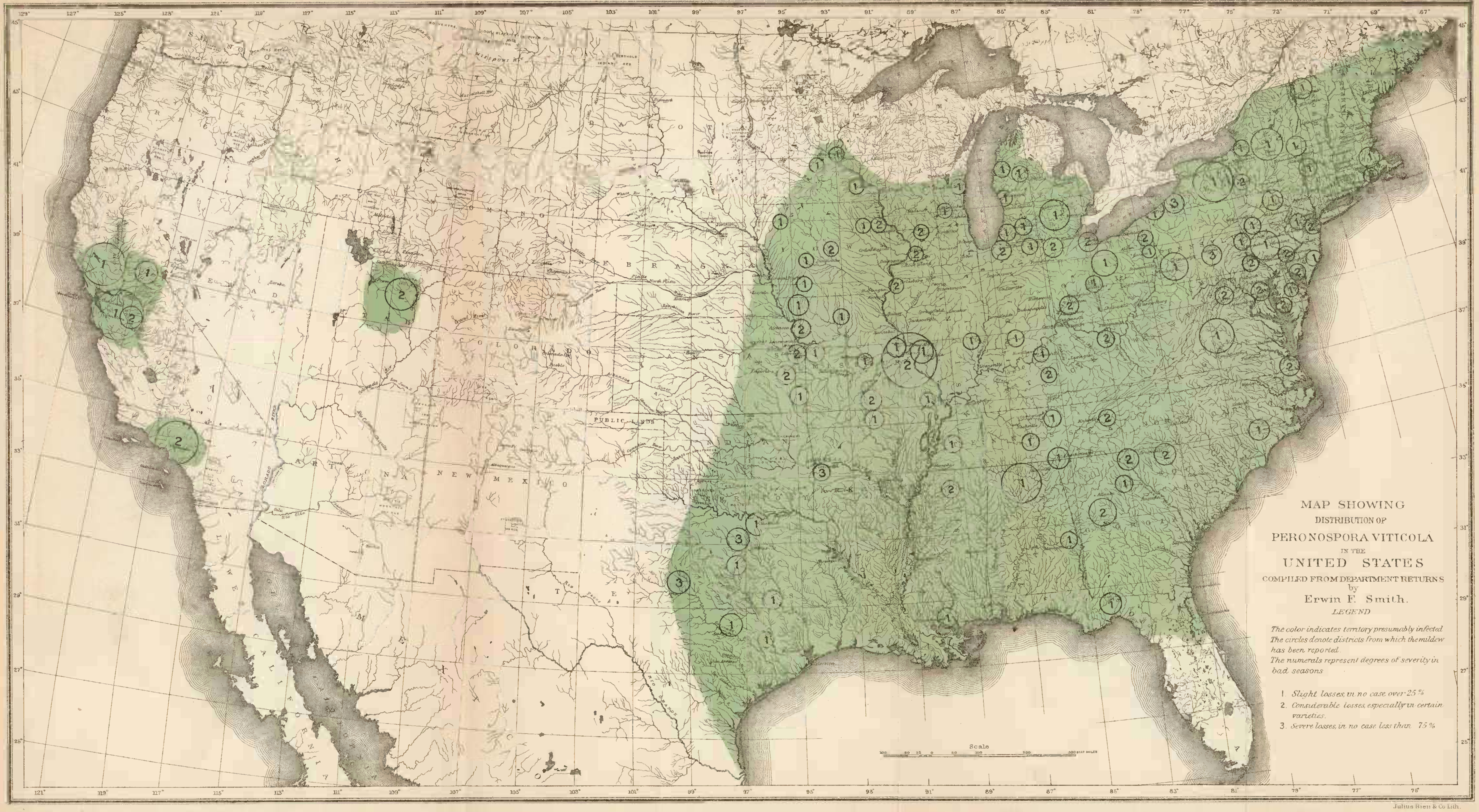
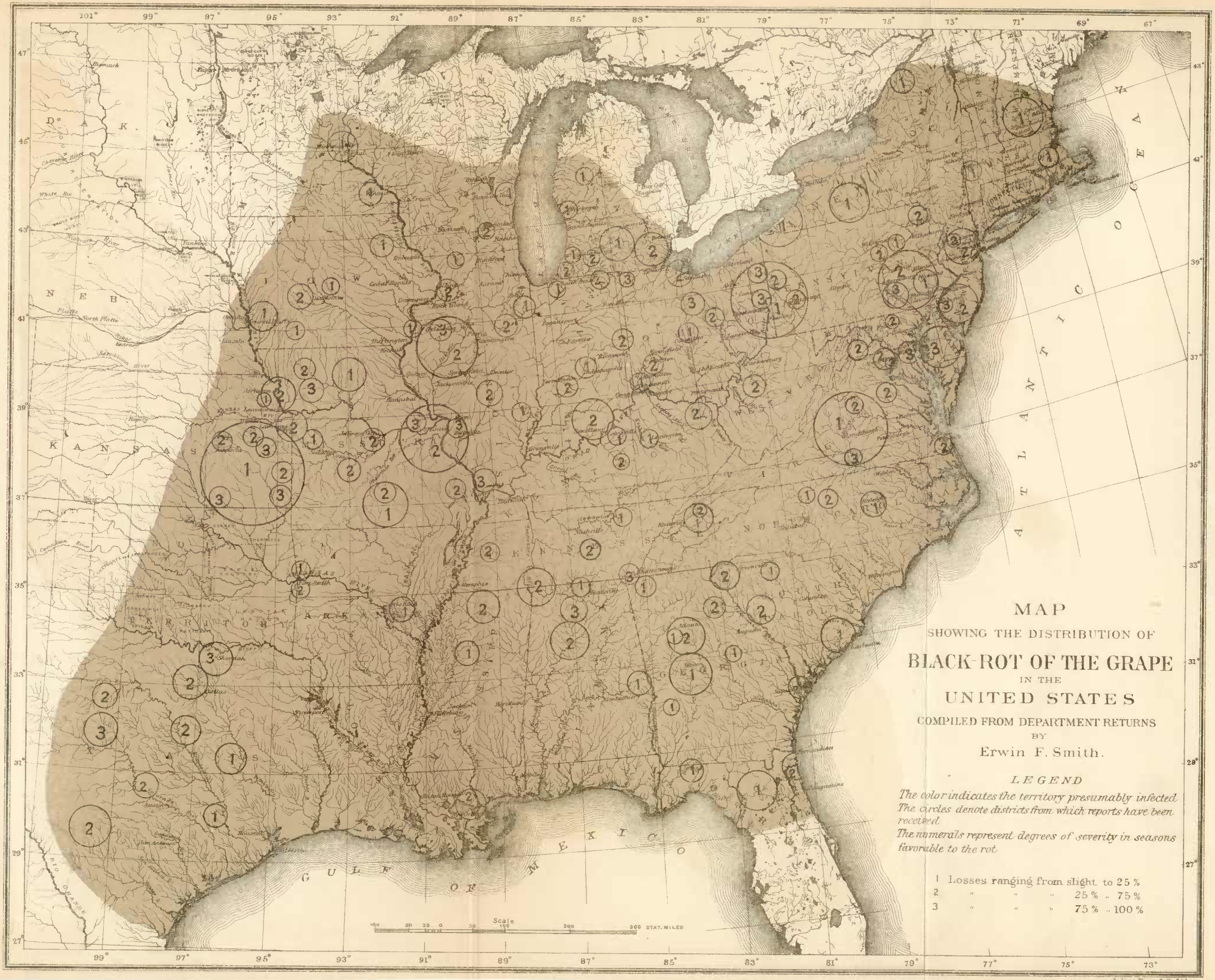


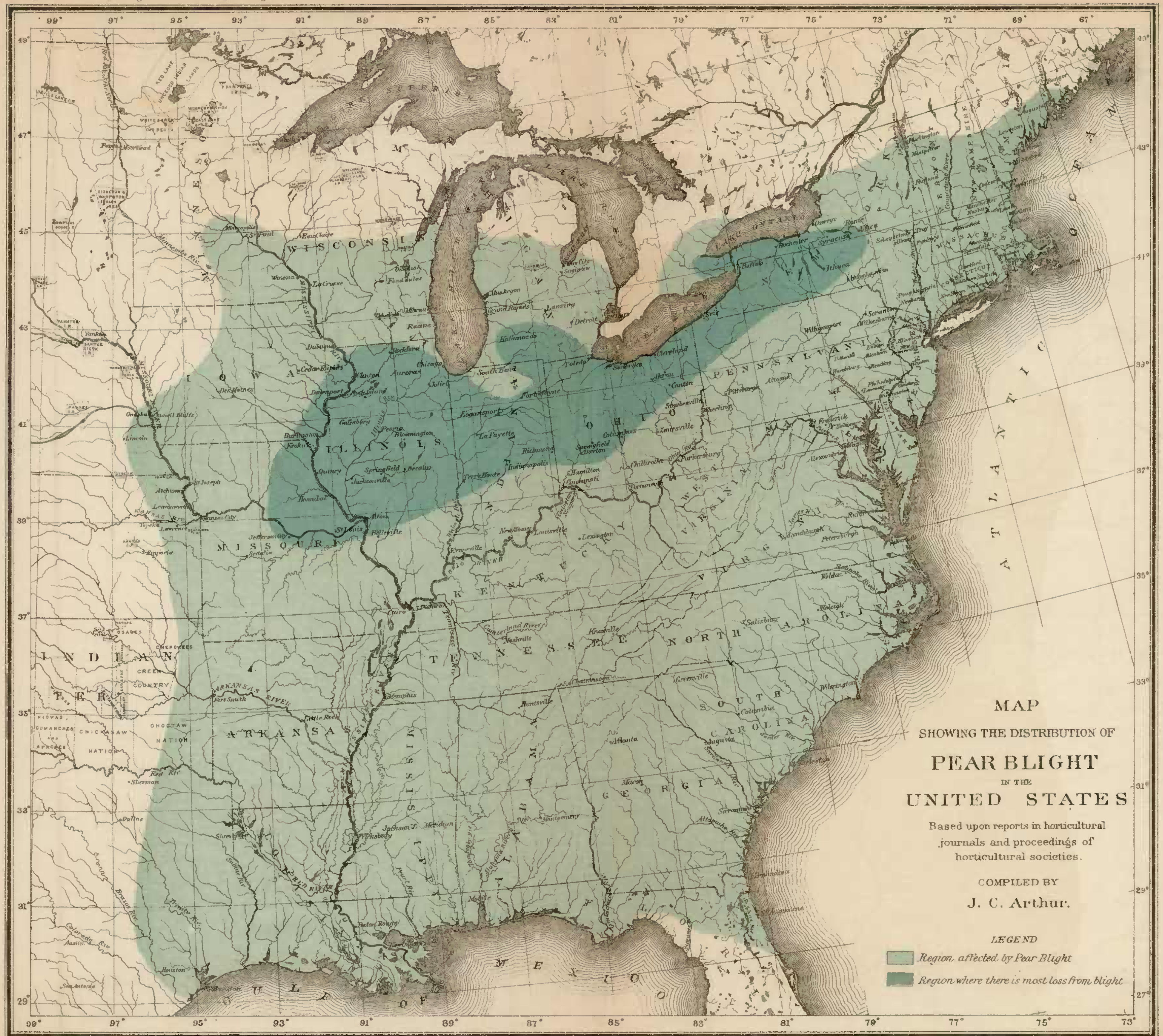
Fig. 2.

SPOT DISEASE OF ORCHARD GRASS (*Scolecotrichum graminis*, Fuckl.).



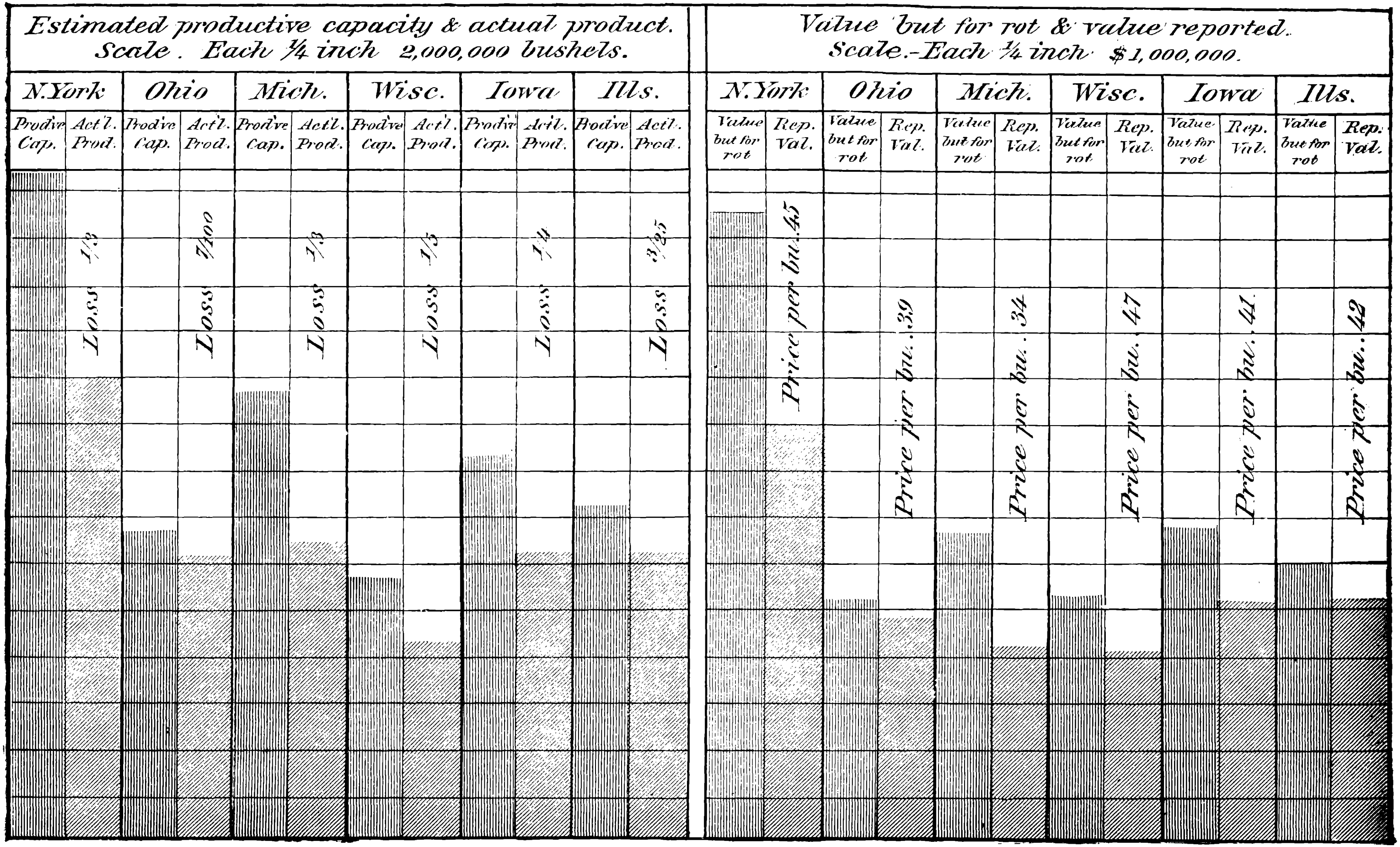
Julius Bien & Co. Lith.


MAP
SHOWING THE DISTRIBUTION OF
BLACK-ROT OF THE GRAPE
IN THE
UNITED STATES
COMPILED FROM DEPARTMENT RETURNS
BY
Erwin F. Smith.
LEGEND
The color indicates the territory presumably infected
The circles denote districts from which reports have been received
The numerals represent degrees of severity in seasons favorable to the rot
1 Losses ranging from slight to 25 %
2 " " " 25 % " 75 %
3 " " " 75 % " 100 %
ATLANTIC OCEAN
GULF OF MEXICO
Scale
STAT. MILES



Julius Bien & Co. Lith

Diagram showing loss from Rot in 1885 in six of the chief potato growing states of the United States. The total loss in these States is estimated at 25,428,031 bushels valued at $10,506,963.



Report of the Mycological Section, U. S. Dept. of Agriculture, 1886.

REPORT OF THE MICROSCOPIST.

SIR: I have the honor to submit herewith my fifteenth annual report. In consequence of an increasing demand for information regarding the characteristics of butter substitutes, I have found it necessary to devote most of my time during the past year to the further investigation of the polarizing properties of animal and vegetable fats, as determined by the use of the microscope, and to devising such other ready, sure, yet inexpensive methods of distinguishing oleomargarine from milk butter as may be readily employed by microscopists and others.

The recent enactment by Congress of an oleomargarine law, which is severe in its penalties, has rendered it all the more important that the methods employed in the detection of butter substitutes should be of the most reliable character, so that on the one hand no one may be unjustly punished for a violation of national or State law, or on the other allowed to escape its penalties.

Pending the appointment of a microscopist in the Bureau of Internal Revenue and the fitting up of a laboratory in that Bureau, I have made a number of examinations of suspected butter, at the request of the Commissioner of Internal Revenue, some of which proved to be oleomargarine.

I have devised during the present year a new and reliable method of detecting cotton-seed oil, benne oil, and ground-nut oil in oleomargarine or other butter substitutes. I have also detected borax in butter, oleo, neutral lard, oleomargarine, and butterine, not observed heretofore. I have found borax in each of twenty samples of butter recently received from the State of Illinois. In December last a butter dealer of this city received from a New York firm ten tubs of what was represented as fresh butter. The lack of butter odor led the merchant to suspect that he had received oleomargarine. At his request I examined samples of this butter under the microscope, but failed to discover in them crystals of fats common to oleomargarine, while well-defined crystals of borax (polarizing bodies) were present in abundance. On boiling these samples the atmosphere of the room became highly charged with the odor of butter. Repeated experiments satisfied me that all the samples were old butter deodorized with borax and by other means.

The following paragraph from the columns of the New York *Sun*, republished in the *Farmers' Review* June 23, 1886, may give a clew to the reason for adding borax, a deodorizing salt, to old butter:

A process of renovating old and rancid butter, now being worked at New Hampton, Orange County, New York, as follows: The rancid stock is purchased in New York City and in Western markets, and costs the concern an average of 10 cents a pound. At the renovating works it is placed in large vats and surrounded by boiling water. When the butter is heated to the right degree all impurities rise to the surface of the melted compound. They are skimmed off, and the remaining liquid

butter is run from the vats to a big circular churn. There the milk and cream are added, and the ingredients are churned until the whole is thoroughly mixed and the new milk and cream have been formed into butter. The fresh butter is a small proportion of the whole, but it seems to leaven the lump, so that when it is treated with butter coloring and salt it is turned out as an apparently prime product of Orange County. The dairy inspector did not seem to regard this manufacturing of new-style butter as objectionable.

I am not prepared to say from personal experience what the physiological effects of the constant use of borax may be, but the following extract from the *United States Dispensatory* will throw some light on this question:

THE PHYSIOLOGICAL ACTION OF BORAX.

In the case of six drams borax has no unpleasant effects except a temporary sense of oppression in the stomach, or, at most, nausea and vomiting. Continued large doses produce the same consequence as the prolonged use of other salts of sodium; liquefaction of the blood and scorbutic symptoms, and sometimes an impetiginous eruption of the skin.

For the accompanying photographic illustrations I am greatly indebted to the late Dr. Bernard Persh, and to Mr. W. H. Walmsley, of Philadelphia, Pa., well known and expert microscopists, Fellows of the American Association for the Advancement of Science. These gentlemen gratuitously devoted time, material, and skill to the work of photographing all the specimens of butter and fat crystals with which I supplied them. For beauty of execution and truthfulness of delineation these illustrations cannot be surpassed, and fully corroborate all that I have heretofore written on this subject.

Much interest in these investigations has been expressed the past year by men of science, among whom are some of the foremost biologists, microscopists, and chemists of the universities and scientific schools of this country. In some cases, on request, I have forwarded them mounted specimens of crystals and photographs of same. The representatives of several foreign powers, resident in this city, have also expressed their personal interest in these investigations, and have requested that copies of all bulletins issued by the Department relating to the microscopical investigation of butter and fats be forwarded to their respective Governments.

I have also made a number of examinations of foodstuffs which have been brought to me personally or sent from a distance.

Examination of fibers from India has also occupied a portion of my time, but these latter investigations are incomplete, and not yet ready for publication.

ARRANGEMENT OF MICROSCOPE, ETC.

For the purpose of microscopic examination of butter and fats the instrument should be so constructed that Nicol's prisms, consisting of a polarizer and analyzer, may be readily attached,* the polarizer below the stage and the analyzer between the objective (one-half inch) and lower end of the tube. By this arrangement a much larger field is obtained than when the analyzer is placed in the upper end of the tube, as is often the case. Having thus adapted the instrument to the work, place a green selenite on the stage and focus the objective to it, when an even green color will be seen. Next place a drop of pure oil on the selenite, focus again, and a green color is again seen.

*I always use a condenser over the polarizer.

Now place a mounted slide of fresh butter, free from salt, over and in contact with the selenite, and you see the same green color. These experiments go to show that polarized light in passing through pure oil and butter does not suffer depolarization. If we now combine a few particles of tallow with oil or butter, and mount the specimen with a glass cover in the usual way, every particle of tallow will exhibit prismatic colors, the butter or oil being represented by the pure green color. In this illustration lies the foundation of my method of distinguishing butter from oleomargarine or other butter substitutes.

CRYSTALLINE FORMATIONS OF BUTTER.

In earlier papers I have stated that if fresh butter is boiled, strained, and cooled slowly, at a temperature of about 60° F., mounted in the usual way, and viewed by polarized light, crystals will be seen, as represented by Figs. 1 to 4, inclusive, Plate I.

Butter which has been improperly kept, subjected alternately to high and low temperatures, will, if treated as above, show crystals represented by Figs. 5 to 8, inclusive, same plate. If kept for a longer period, say from two to three months, stellate crystals appear, which in turn change during the process of fermentation to amorphous.

These varied transitions can only be observed by keeping on hand the original samples for a long period of time.

CRYSTALS OF FATS.

In preparing animal and vegetable fats for the purpose of developing their normal crystals their natural consistency must be considered. Some fats contain a much larger proportion of olein than others, that of fish, fowl, and swine, for instance, while the fat of the ox, sheep, and deer contains a smaller proportion of olein. The first named may be rendered, cooled, and examined without the addition of oil. The last mentioned will require oil to bring them to the consistency of butter. For this purpose I use pure cotton-seed oil. It is always desirable to simmer fats slowly, as by so doing they are not so liable to scorch. If cooled at a temperature of about 60° F. for about ten hours a perfect crystallization results. If quickly cooled, say at a temperature of about 32° F., the crystals will not form properly, and in some cases will not be observed.

HOW TO MOUNT CRYSTALS OF FATS.

Describe a varnish ring, by means of a turn-table, using copal or other varnish. In the center of this ring place some lard in quantity about the size of a small pin's head. Place over this a corresponding amount of cotton-seed oil, mix with a point, place a cover, corresponding in diameter with that of the ring, over and in contact with the soft varnish, and press gently. The specimen may thus be viewed by plain or polarized light. Other fats having very small crystals may be mounted in this way. Globose crystals of butter or of other fats of large diameter require deep rings of a permanent character.

Owing to a diversity in the size of butter crystals and the crystals of other animal fats, I have found it necessary to use powers varying from fifty to five hundred diameters.

BEEF-FAT.

Crystals of beef-fat are very unlike those found in what is known commercially as "oleo." Manufacturers of oleomargarine generally prefer oleo, because it is more digestible than beef-fat and approaches nearer the character of pure butter. Rendered beef-fat, when cooled, shows crystals of a branched and foliated character, radiating from a common center and very distinctly marked. Plate I represents crystals of the fat of the omentum, kidney, marrow of femur, and round of beef. (See Figs. 21, 22, 23, and 24.) Generally each group of branches is imbedded in a mass of translucent fat (see Fig. 23, Plate I), imperfectly represented by photography, yet distinctly seen by the microscope.

OLEO.

"Oleo," an extract of beef-fat, is used very extensively in combination with neutral lard, which gives the substance toughness, prevents it from crumbling, and produces a closer resemblance to butter. Butter substitutes thus made cut and spread on bread like butter. As sold, oleo is not unlike butter. It has a slight taste of butter when fresh, but is much firmer to the touch. It has also a slight animal odor. Every specimen I have examined has contained borax, used, as I am informed, for the purpose of destroying the animal odor. This it accomplishes to a great extent. When oleo is heated to a temperature of about 300° F. and cooled slowly, it yields crystals of a globose form, which exhibit a cross, as in Fig. 17, Plate I. These break up in course of time into highly stellate forms, the spines of which resemble thorns and proceed from a common center (see Fig. 18). The primary oleo crystal is generally of a rich orange color, although it sometimes appears pure white and very small, say about the one-thousandth of an inch in diameter. (See description of oleo crystals, Plate IV.) I have produced oleo crystals as large as the one-hundredth of an inch in diameter by boiling Armour's oleo with yellow oxide of lead. These have a dull orange color and appear very smooth. They also break up into highly spinous crystals, but as thus far observed do not show such forms as Figs. 5, 6, 7 and 8, common to butter, Plate I. See the spinous crystals of oleo, Plate IV, as compared with tertiary crystals of butter, 9, 10, 11, and 12, and with those of lard, 19 and 20, Plate I. Compare also crystals of beef-fat, 21, 22, 23, and 24, with those of oleo.

I have found in all my experiments, using fresh material, that when oleo is boiled in cotton-seed oil, say one-third oil to two-thirds oleo, the globose crystals are invariably small as compared with those of butter. In color the butter crystal is either yellow or pure white, while the oleo crystal is of a deep orange or white. In butter the small immature secondary crystals, Fig. 2, Plate I, represented by small white globose bodies, differ from the very small crystals in Fig. 17, which show a cross, however minute they may be. Compare also the butter crystal, Fig. 1, Plate I, 110 diameters, with the oleo crystals, Fig. 17, 140 diameters. Oleo crystals, Fig. 2, Plate IV, are also 140 diameters, and represent the largest crystals of oleo I have seen, produced without the aid of chemicals. In Plate IV, Figs. 1, 2, 4, and 11, represent globose crystals of boiled oleo as seen by polarized light; Figs. 3, 5, 6, 7, 8, and 9 their first change in process of decay. Fig. 12 represents a crystal of oleo and neutral lard compounded with salt and water and boiled after the fashion proposed

by Professor Weber. The photograph is a reproduction of one sent by Professor Weber with the statement that he could not distinguish the crystal thus made from real butter, represented by Fig. 10, as photographed by Professor Detmers. Boiled butterine (Figs. 13 and 15), he said, was equally indistinguishable, whereas 13 and 15 are simply poor representations of the oleo crystal. Fig. 14 is a photograph, by the late Doctor Persh, of a crystal of boiled butter. On contrasting the butter photographs of Plates I, II, and III with those of the oleo (Plate IV), the difference is seen to be great. But it should be borne in mind that in the practical work of detecting a butter substitute by the microscope the suspected substance must be examined first in the unboiled condition. The oleo crystals alluded to are absent in all commercial butter substitutes.

NEUTRAL LARD.

Neutral lard is a product of leaf-lard rendered at the lowest possible temperature. It is said that soda or a small portion of potash added in the rendering facilitates the maceration of the adipose tissue and secures a greater amount of the product. The remnants of tissue are generally observed in the lard thus treated by means of transmitted light, and appear as brown bodies frequently enveloped in globules of oil. Neutral lard in bulk is whiter than common lard or "oleo," and contains less stearin than the former, is firmer to the touch, and is deodorized with borax. The crystals, when immature, are small as compared with butter crystals, measuring about one two-thousandths of an inch in diameter, sometimes showing a faint cross, but when large and well formed they do not exhibit a cross. These crystals are composed of acicular spines, proceeding from a common center, as seen in Fig. 5, Plate VI.

OLEOMARGARINE.

In some cases freshly made oleomargarine, in consequence of being suddenly chilled in the final stage of manufacture, shows no fatty crystals when examined under the microscope.

I have lately discovered that a small portion of oleomargarine of this character, mounted on a glass slide 3 by 1 inch, under a cover-glass, heated over a spirit-lamp until the oleomargarine melts, and then cooled slowly, or until the fatty compound appears whitish (a process of about five minutes' duration), is seen on examination under the microscope in the beautifully crystallized forms common to artificial butter. Should the specimen prove to be largely composed of stearin, the crystals will be quite large and well defined, and may be observed in the act of crystallizing. Figure 10, Plate V, represents specimens of this character. Several samples of oleomargarine containing large quantities of stearin reduced with oil to the consistency of butter, colored to imitate butter, have been forwarded to this Department during the present year by the Hon. J. K. Brown, dairy commissioner for the State of New York.

Thus far I have not found any commercial oleomargarine that has not, on examination by plain or polarized light, exhibited at once well-defined crystals of fats.

EXTRACTION OF COTTON-SEED OIL FROM OLEOMARGARINE.

I read a paper relating to the detection of oleomargarine before the chemical section of the American Association for the Advance-

ment of Science, August, 1886, at Buffalo, and exhibited about half an ounce of cotton-seed oil which I had drained, by a simple method, from a sample of oleomargarine.

When I test for cotton-seed or benne oil in oleomargarine or other butter substitute I boil about six ounces of the sample and allow it to cool and granulate, the object of which is to facilitate the escape of the oil through the interstices formed by the fatty granules. Having thus secured the most favorable conditions for drainage, I remove the oil by means of a Bunsen filter-pump. (See Plate VII.) By this means I have procured within a few hours, at a temperature of about 78° F., about a gill of cotton-seed oil from three-fourths of a pound of oleomargarine. When the oil is in excess it may be drained at a lower temperature. The oil of butter may be removed in this way to a great extent, but requires a higher temperature to operate well. About 78° F. is suitable for some varieties of butter. Butter oil, cotton-seed, benne, and other oils may be readily distinguished one from the other by well-known tests. At 65° F. oil of butter is fluid. Cotton-seed and other oils used in oleomargarine are liquid at a much lower temperature than oil of butter. When a foreign oil is found in a substance sold as pure butter the substance thus compounded is an oleomargarine under the law.

THE BUNSEN FILTER-PUMP.

Plate VII represents the ordinary Bunsen filter-pump. The pump at A is firmly attached to a faucet which has a good flow of water. The water flows through to B; thereby exhausting the air from the bottle C, through the tube E, and in turn from the bottle D through the connecting tubes F. The oleomargarine, previously boiled and freed from water by decantation and cooled, is put into the funnel G, into which a coarsely perforated platinum cone, filled with absorbent cotton, has been fitted. The water is now turned on and the apparatus set to work. As the air is exhausted from the two bottles the oil in the oleomargarine is forced through into the bottle D. The identity of the oil is then tested. Two bottles are used, so that in case of any inequality in pressure or flow the water backs into C and not into D, thus preserving the oil resulting from the operation free from water or any foreign substance.

COTTON-SEED OIL USED IN OLEOMARGARINE.

The *United States Dispensatory* thus describes cotton-seed oil, which is used as a constituent of oleomargarine in some factories:

> Bleached cotton-seed oil is perfectly transparent and has a pale straw color, a bland, nut-like taste, and a neutral reaction. Its specific gravity at 15° C. (59° F.) is .925—.927 (.920—.930, U. S. P.); that of crude oil .930—.932. It is very sparingly soluble in alcohol, but dissolves readily in ether, chloroform, benzine, &c. Near 5° C. (41° F.) the oil begins to deposit palmatin, but it does not congeal until cooled to —1° or —2° C. (30° or 28.4° F.). Exposed to the air the oil gradually thickens, but it does not solidify. Cotton-seed oil consists chiefly of olein and palmatin.

BENNE OIL.

The following characteristics of benne oil, used in the manufacture of oleomargarine, are also from the *United States Dispensatory:*

> Benne oil has a yellow color, usually of a deeper hue than expressed almond oil, is thinner at ordinary temperatures than most other fixed oils, is nearly inodorous,

and has a bland and agreeable peculiar taste; and the specific gravity, .923° at 15° C. (59° F.). Near the freezing point of water it becomes opaque, and congeals usually at about −5° C. (23° F.), while the oil extracted by solvents congeals at about 5° C. (41° F.), forming a yellowish-white mass. It is a non-drying oil, and on exposure to air does not readily turn rancid. Oil of benne is obtained by subjecting benne-seeds to pressure. The yield is in the neighborhood of 50 per cent. of the weight of the seeds. About 14,000 gallons of this oil were imported into the United States in 1876 and 126,271 gallons in 1883.

PEANUT OIL.

This oil, so much used in the manufacture of oleomargarine, is thus described by the same authority:

It is prepared from *Arachis hypogæ*, Linne (Bentley and Trimen Med. Plants, p. 75), an annual herb indigenous to tropical America, and now cultivated throughout the tropics. It is known in Brazil as *amendoim* or *mandobim*. The seeds contain about 45 per cent. of oil. This is pale yellow, thin, has the density .920, and a peculiar nutty flavor, becomes turbid at about 3° C. (37.4° F.), and congeals near—5° C. (23° F.). Nitrous acid causes the oil to congeal to a whitish mass; nitric acid colors it reddish, and sulphuric acid grayish-yellow, then green-brown. It consists of the glycerides of palmitic, *arachic*, and *hypogæic* acids. The latter crystallizes in needles, which melt near 35° C. (95° F.) Under the name of *katchung* oil this oil is largely used in India in the place of olive oil.

BUTTER TESTS CORROBORATED.

The *Iowa State Register*, of the 9th of January, 1887, corroborates these tests in the following words:

The correctness of butter tests is a matter of interest to every citizen of Iowa, and the course of the Government officials in this matter has been closely watched. The result of the recent tests made in this city had a very beneficial effect upon public sentiment, which will be emphasized by the knowledge that Dr. Field, of this city, has made a careful microscopic test of the same samples and fully corroborates every one. In conversation with a *Register* scribe yesterday, Mr. Schermerhorn made the following statement of these last tests: "In view of the fact that the reliability of butter tests have been brought into question, I desire to state that I furnished to Dr. A. G. Field, of this city, eight packages of butter and mixtures for microscopical testing. They consisted of various mixtures of lard, salt, butter, butterine, and also pure butter of various ages and modes of manufacture. With the exception of one package of genuine butter four years old they all had the appearance of good butter. They were numbered and the composition of each recorded, but of which Dr. Field knew nothing before making the examination. In every case his report was correct. He stated that he followed the method of Dr. Thomas Taylor, of Washington, D. C., relying principally upon the form of crystal and the use of polarized light.

THOMAS TAYLOR,
Microscopist.

Hon. NORMAN J. COLMAM,
Commissioner.

PLATE I.

CRYSTALLINE FORMATIONS OF BUTTER AND FATS.

FIGS. 1, 2, 3, AND 4. Represent primary crystals of butter. x 80 to 110.
FIGS. 5 AND 6. Secondary crystals forming within primary crystals.
FIGS. 7 AND 8. Secondary crystals which have separated from the primary forms. x 80 to 110.
FIGS. 9, 10, AND 11. Tertiary crystals of butter. x 80 to 140.
FIG. 12. Tertiary passing into the amorphous. x 140.
FIGS. 13, 14, 15, AND 16. Represent oleomargarine. x 80 to 110.
FIG. 17. Oleo x 140. This crystal is not found in unboiled oleomargarine.
FIG. 18. Oleo in its second stage, as seen in oleomargarine as sold.
FIGS. 19 AND 20. Common lard. x 140 to 400.
FIGS. 21, 22, 23, AND 24. Crystals of beef-fat from various tissues of the ox. (Omentum, kidney, marrow of the femur, and round.)

PLATE II.

CRYSTALLINE FORMATIONS OF BUTTER AND FATS, AS SEEN BY POLARIZED LIGHT AND SELENITE PLATE.

FIGS. 1, 2, 3, AND 4. Represent primary crystals of butter. x 80 to 110.
FIGS. 5 AND 6. Secondary crystals forming within the primary.
FIGS. 7 AND 8. Secondary crystals which have separated from the primary forms. x 80 to 110.
FIGS. 9, 10, AND 11. Tertiary crystals of butter. x 80 to 140.
FIG. 12. Tertiary passing into the amorphous. x 140.
FIGS. 13, 14, 15, AND 16. Represent oleomargarine. x 80 to 110.
FIG. 17. Oleo. x 140.
FIG. 18. Oleo in its second stage. x 140.
FIGS. 19 AND 20. Common lard. x 150.
FIGS. 21, 22, 23, AND 24. Crystals of beef-fat from various tissues. (Omentum, kidney, marrow of femur, and round.)

PLATE III.

CRYSTALLINE FORMATIONS OF BUTTER.

FIGS. 1, 2, 3, 6, 8, 9, 12, AND 14. Primary crystals of normal butter. x 80 to 110.
FIGS. 4, 7, AND 10. Primary crystals showing "secondaries" forming.
FIGS. 13 AND 15. Secondary crystals of butter. x 80 to 140.
FIGS. 5 AND 11. Tertiary crystals of butter. x 80 to 140.

PLATE IV.

CRYSTALLINE FORMATIONS OF OLEO AND BUTTER.

FIGS. 1, 2, 4, AND 11. Crystals of boiled oleo (Armour). x 70 to 140.
FIGS. 3, 5, 6, 7, 8, AND 9. Crystals of boiled oleo in process of decay. Such forms are frequently observed in oleomargarine. x 140.
FIG. 10. The butter crystal as photographed by Detmers.
FIG. 12. A crystal of oleo and lard made by Professor Weber, which he says cannot be distinguished from that of the pure butter. (See Figs. 10 and 14.)
FIGS. 13 AND 15. Crystals of boiled butterine as prepared by Professor Weber and photographed by Professor Detmers, representing the butter crystal according to Professor Weber.
FIG. 14. The true butter crystal, photographed by the late Dr. Bernard Persh.

Compare the above plate with the transition stages of butter crystals, Plate I.

PLATE V.

CRYSTALLINE FORMATIONS OF OLEO AND OLEOMARGARINE.

FIG. 1. Boiled oleo by plain light, exhibiting spines. x 140.
FIG. 3. Boiled oleo by polarized light, showing a cross. x1 40.
FIGS. 2, 4, 5, 6, 9, 11, 12, 13, 14, AND 15. General appearance of oleomargarine as sold in the market. x 75 to 110.

FIG. 7. Armour's oleomargarine boiled and cooled. x 140.
FIG. 10. A specimen of oleomargarine composed mostly of stearin and cotton-seed oil. x 110.
FIG. 8. Boiled butterine (Armour's make), showing the oleo crystals. x 110.

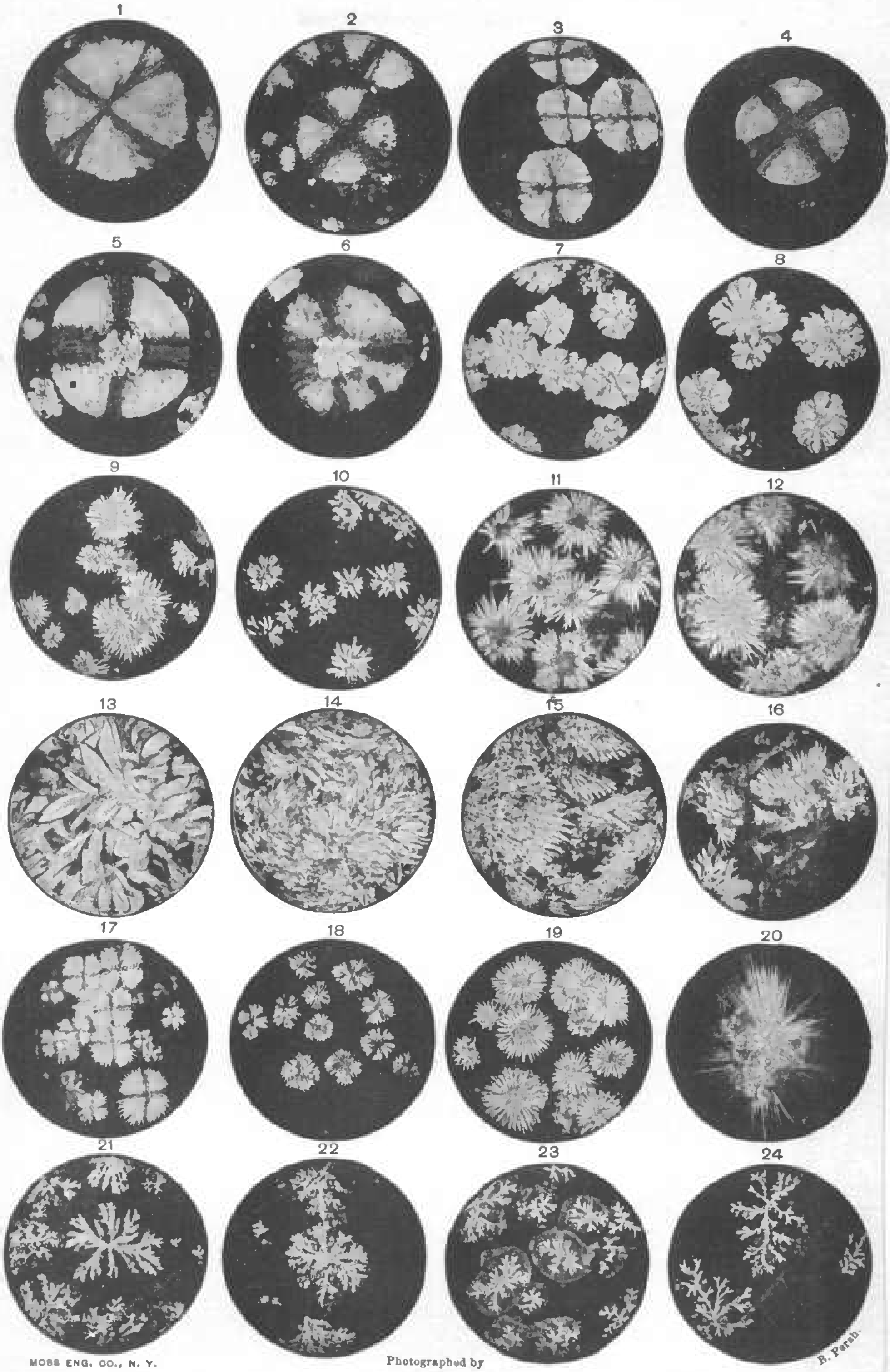
The above crystals were all photographed by polarized light, except in the case of Fig. 1, which was photographed by plain light.

PLATE VI.

CRYSTALLINE FORMATIONS OF VARIOUS FATS.

FIGS. 1 AND 3. Respectively, primary and secondary crystals of loon fat. x 110.
FIGS. 2 AND 8. Primary and secondary crystals of musk-rat fat. The primary (No. 2) are always very small, measuring about three one-thousandths of an inch in diameter.
FIG. 4. Crystals of oleo. x 140 diameters. (Extract of beef fat.)
FIG. 5. Crystals of common lard by plain light. x 400.
FIG. 6. Secondary crystals of butter. x 110.
FIG. 7. Crystals of beef fat. x 140.
FIG. 9. Crystals of deer fat. x 140.
FIG. 10. Lard by plain light. x 140.
FIG. 11. Crystals of the solid fat of cotton-seed oil. x 110.
FIG. 12. Neutral lard crystals, immature. x 140.

CRYSTALLINE FORMATIONS OF BUTTER AND FATS.



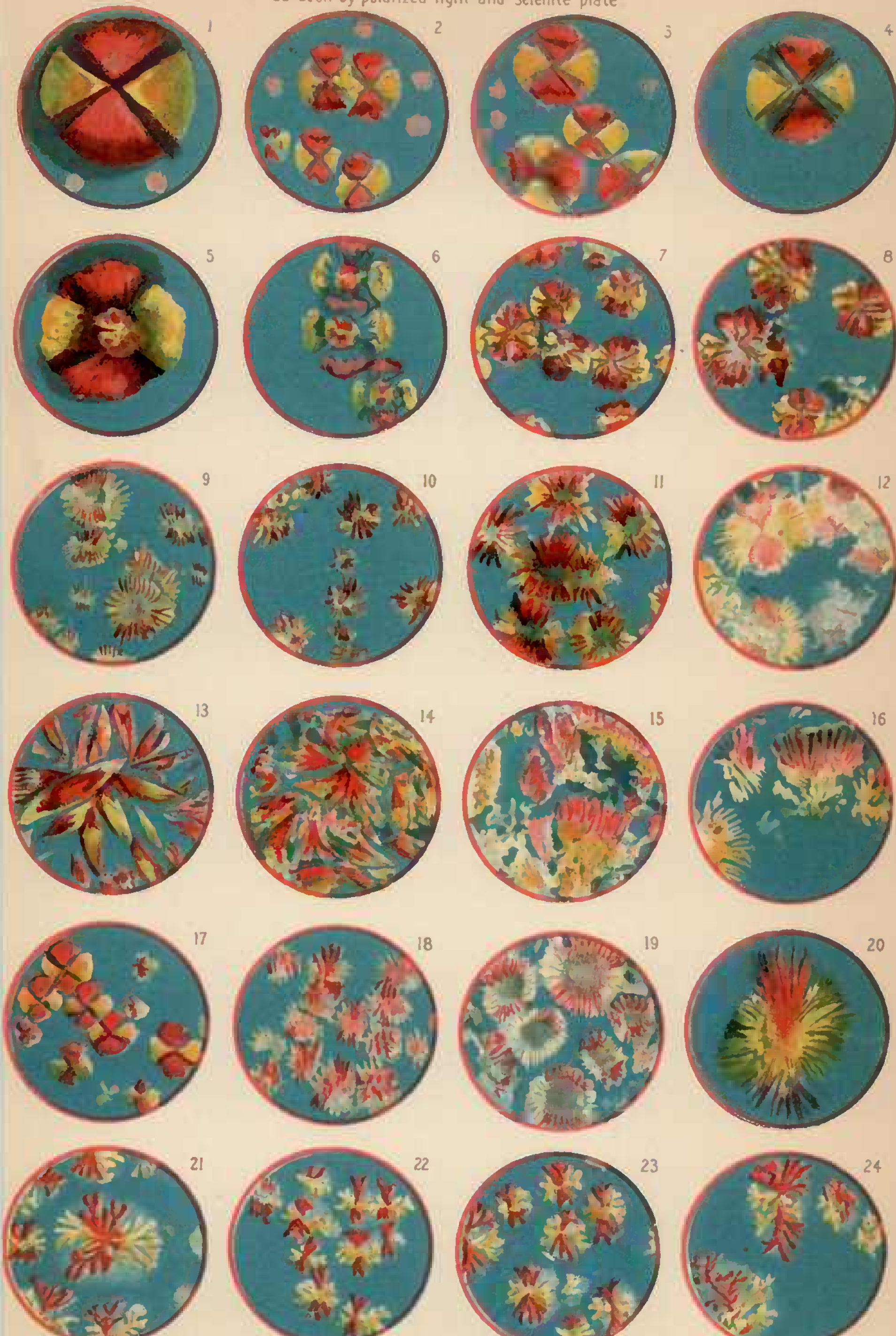
MOSS ENG. CO., N. Y.

Photographed by

Plate II.

CRYSTALLINE FORMATION OF BUTTER AND FAT.

as seen by polarized light and selenite plate

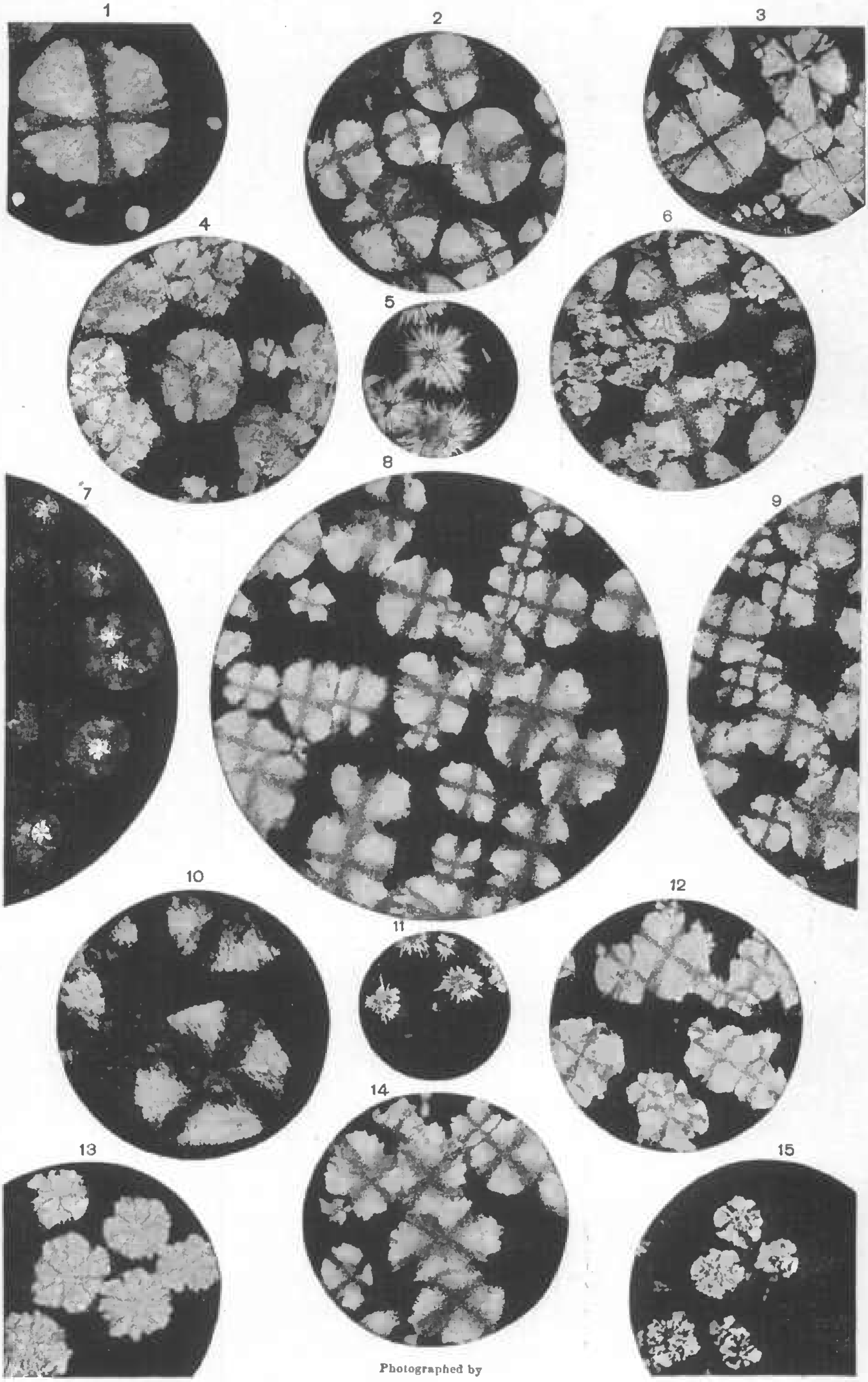


T. TAYLOR, del.

GILES LITHO & LIBERTY PRINTING CO N.Y.

PLATE III.

CRYSTALLINE FORMATIONS OF BUTTER.

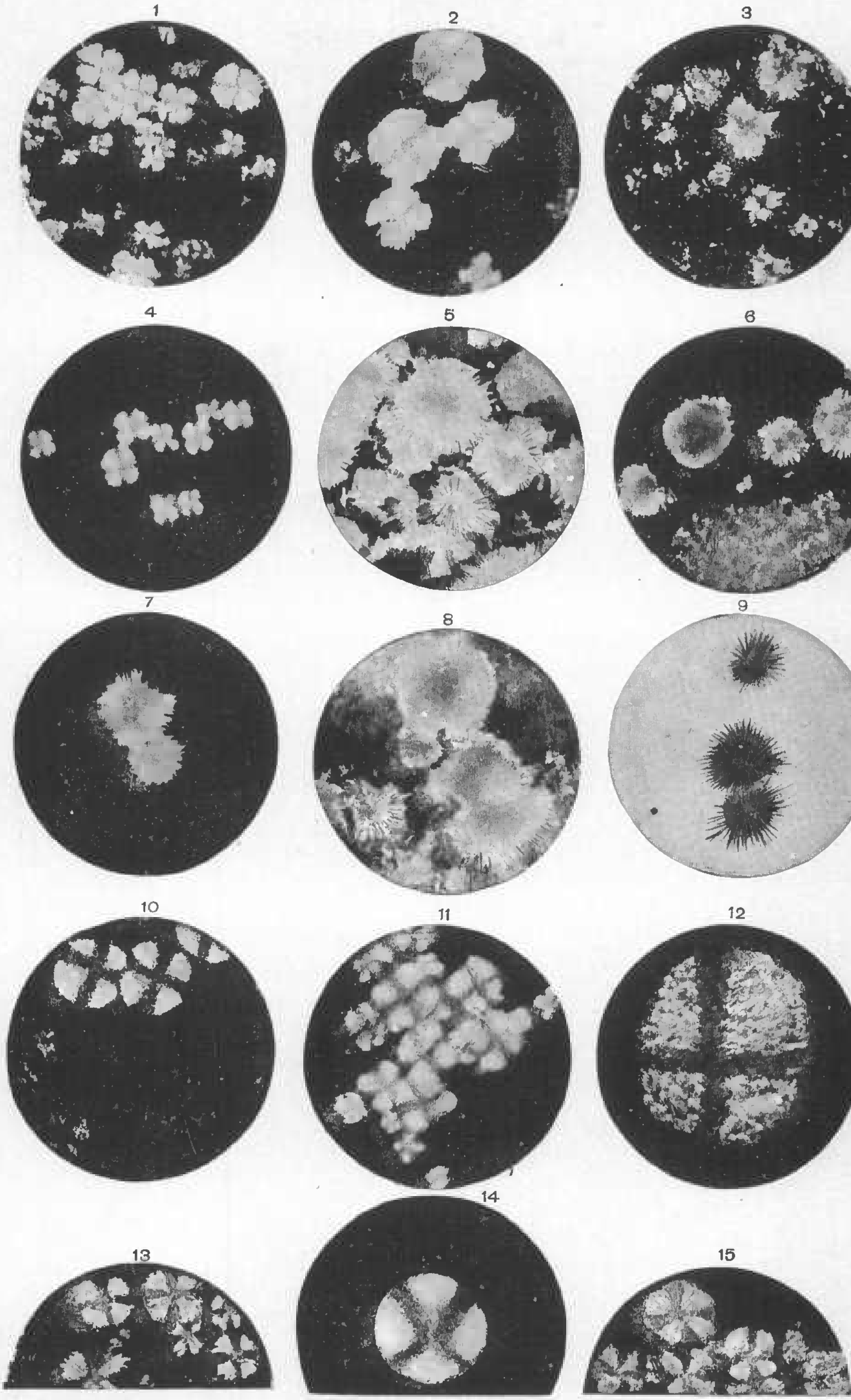


MOSS ENG CO., N. Y.

Photographed by
Persh, Walmsey and Gascoyne.

PLATE IV.

CRYSTALLINE FORMATIONS OF "OLEO" & BUTTER.



MOSS ENG. CO., N. Y.

B. Persh and Detmers, Photogs.

PLATE V.

CRYSTALLINE FORMATIONS OF "OLEO" & OLEOMARGINE. BOILED AND RAW.

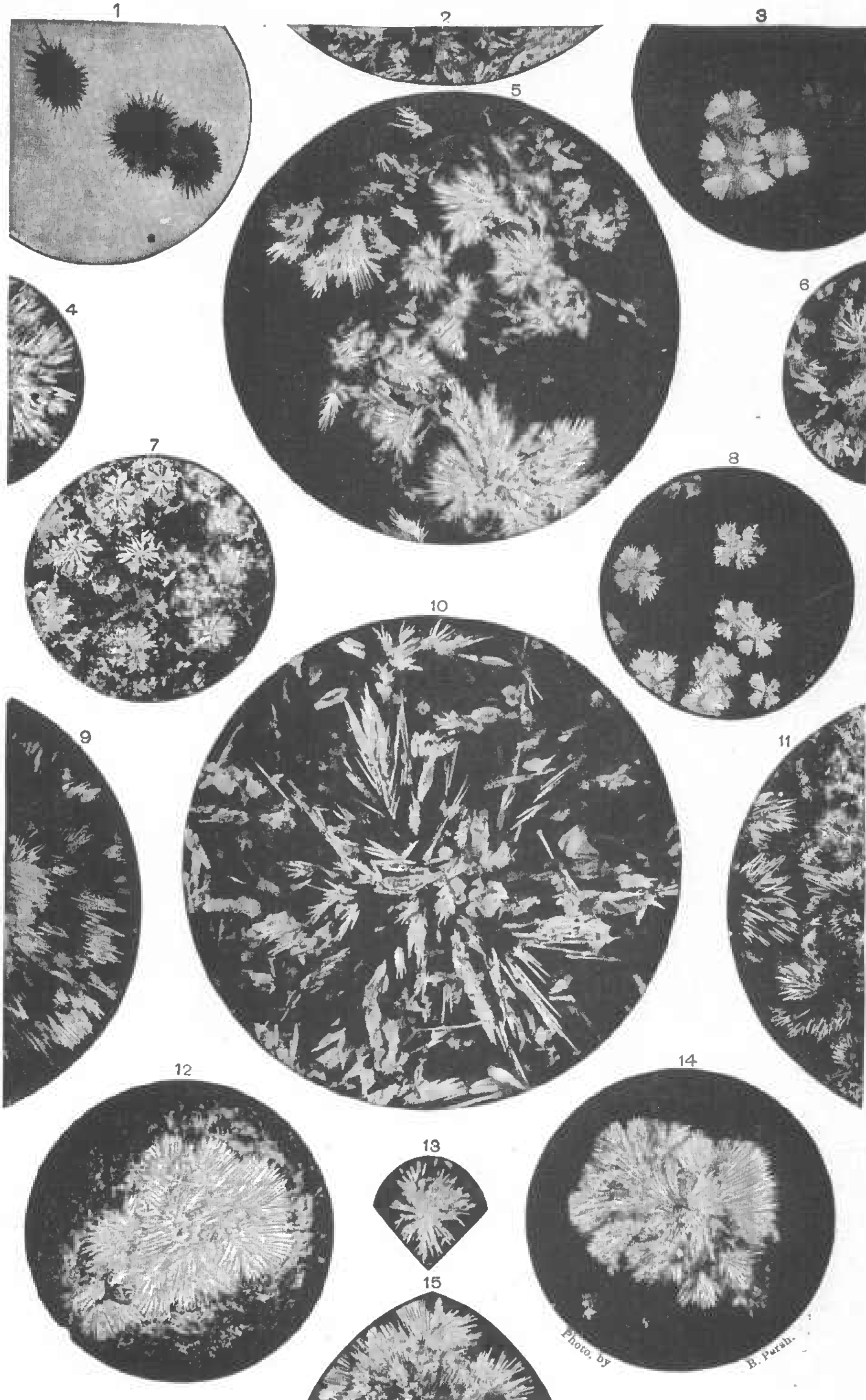


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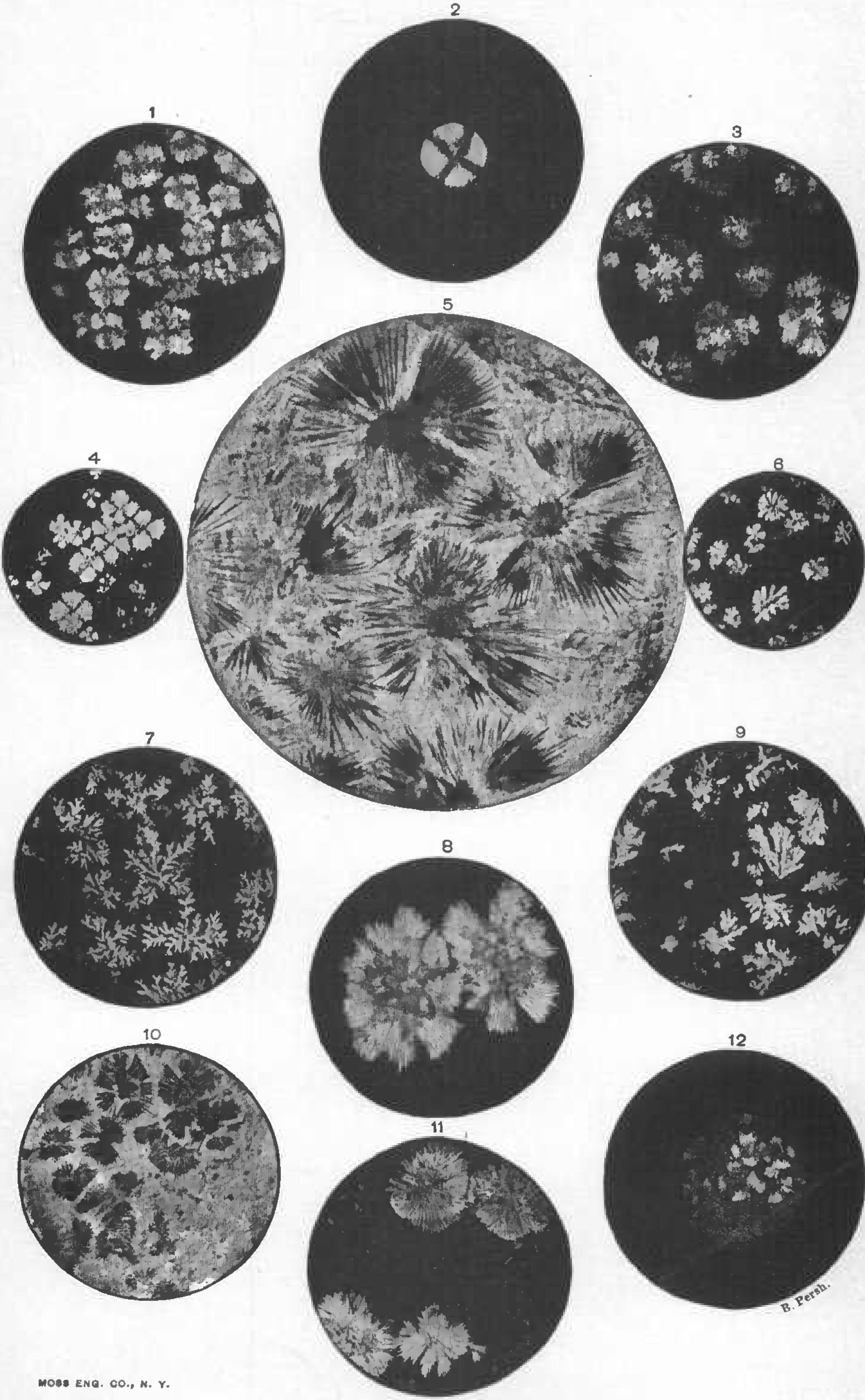
PLATE VI.

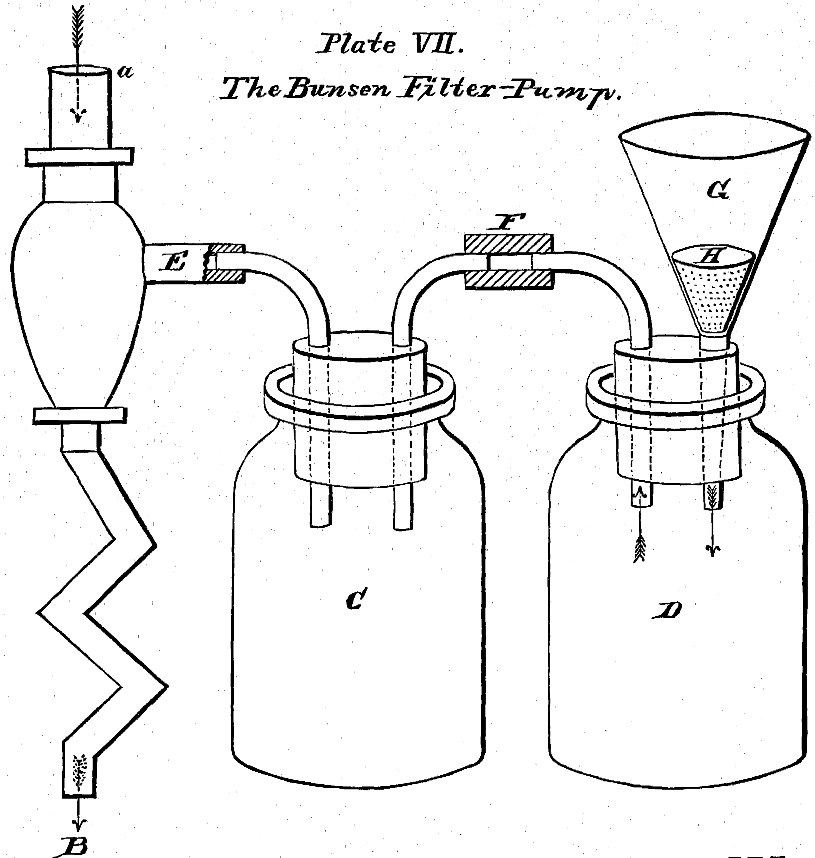
CRYSTALLINE FORMATIONS OF LARD AND OTHER FATS.



MOSS ENG. CO., N. Y.

Plate VII.

The Bunsen Filter-Pump.



C.R. Burr, Del.

REPORT OF CHIEF OF FORESTRY DIVISION.

SIR: I have the honor herewith to transmit my annual report for the current year, embracing in its first part, besides the outline of work pursued in this Division, a brief review of the questions which underlie the consideration of Government action in regard to a forest policy, and also an account of the present condition of forestry in the United States. In the second part I have attempted to state briefly the elementary principles which must be understood before we can hope to establish a successful forest management. In this part the often-asked questions, "What to plant" and "How to plant" have received a broad consideration, such alone as can be given to them in a report of limited size and for a country with such diversity of soil, climatic, floral, and economic conditions.

I beg leave to report that with the studies of the biology of our timber trees, just inaugurated, a new and important line of work has been begun, which, if continued in the same spirit as undertaken, may eventually form the basis of future American forestry; teaching us the life-history of our important forest trees and the conditions upon which their development in the forest depends; deducing from observations made from practical rather than botanical points of view rules of management directly applicable to the forester, a work which has not heretofore been systematically attempted. This most necessary work will naturally require a series of years of patient labor and observation before the results can be generalized upon and practically applied. It can only be expected to progress satisfactorily if liberal provision is made for those engaged in it, who should be persons of special fitness, with ample means to supply needed elementary knowledge.

With its present appropriation the Division cannot, in my opinion, satisfactorily undertake extended forest statistical inquiries, and should, therefore, confine itself mainly to the work of establishing the methods upon which forest planting and forest management can be carried on in our country with our native timber trees.

The distribution of seedlings, the only satisfactory manner of supplying plant material, would be of great benefit to the Western tree planters especially, and would enlarge the area of forest planting; but without facilities to grow the supply, without the means of satisfying the demand of every applicant, and in the absence of a discriminating system of distribution, this mode of encouraging forestry has not yet borne the results which might be expected from it.

As will appear from the wording of the Act, instituting its work in the year 1876, the Forestry Division was originally intended to furnish data upon which a true conception might be formed of the condition and importance of our forests and forest supplies, and by presenting the methods of management pursued in other countries to aid the legislator in formulating a forest policy for this country.

This work, mainly of statistical or historical character, so far as general information goes may be deemed concluded, and although

the forest statistics relating to our own country, even as supplemented by the excellent work of the Tenth Census in Volume IX, cannot be said to represent more than approximations, owing to the insufficiency of funds annually allowed for the difficult and elaborate task of such statistical collection; yet the information embodied in the four volumes of forestry reports issued from this Department, in addition to the annual reports and other similar forestry publications, official and unofficial, must be considered sufficiently extensive to fairly show the deplorable condition of our forestry, the importance and need of a systematic forest policy, its bearings upon national economy, and its requirements at the hands of legislators as well as of wood consumers.

That a more general and practical application of this preliminary knowledge cannot yet be recorded, may be due to the difficulty of extracting from the mass of matter accumulated in these reports the important facts upon the consideration of which action must proceed. It may be desirable, therefore, at the end of the first decade of forestry investigations, to summarize briefly the results, and to present a concise picture of our present forest and forestry conditions.

SIGNIFICANCE OF FORESTS.

It is a generally recognized fact that forests have always been important factors in the national life, the civilization and the progressive development of the human race.

Their influence is of duplex character—direct and indirect.

As sources of a raw material which enters into almost every branch of human industry and manufacture, substitutes for which are not easily found, their direct importance and the need of their perpetuation is obvious. In this respect the forests of the whole world might be considered tributary to our markets; but not only would the importation of a bulky material from distant parts be exceedingly expensive and almost impracticable for the enormous quantities required by us, but other nations are awake to the danger of diminished forest products and are restricting their wood exports.

The question of a home supply of raw material is nowhere more important than in the matter of forest products.

While for more than a century alarmists have prophesied a dearth of timber, and by their clamor have induced more careful husbanding of forest resources in Europe, apparently their prophecies have not been fulfilled. But there can be no doubt that the conditions favorable for a fulfillment of such predicted danger are growing with the increase of the world's population and with the greater requirements of an advancing civilization. While in many cases wood is successfully supplanted by other materials, yet the substitutes do not seem to come in proportion to the increased demand and decreased supply. There can be no doubt that wood is a *convenience* which ought to be preserved in sufficient quantity for the use of the human race.

The tendency of nature to clothe waste places with wood growth has been claimed as sufficient to restore the ravages made upon the timber resources by man. At one time no doubt the unaided productions of nature were sufficient to provide man with food without much trouble, making the use of plows and fertilizers unnecessary. But the present era, it seems, cannot find methods intensive enough to feed its multitudes. Nobody would deny the need of agriculture. In the same manner, with the increasing need of agricultural lands, the

relegation of the forest to the poorer soils and the decrease of its area will necessitate intensity in methods of its production and a careful management—a system of forestry.

MECHANICAL INFLUENCE.

The mechanical influence of the forests on mountain slopes and crests, as regulators of the water supply in springs and brooks which feed the rivers of the plain, and in counteracting the destructive tendency of these waters, is abundantly proved and well understood.*

The amount of rain which reaches the soil is naturally smaller in the forest than on the open field; but in the forest the moss and leaf-mold act as a sponge, absorbing all the rain or snow which reaches them, and only gradually giving up the same to the soil, while the open field, and still more the denuded hillside, allow the water to flow off rapidly, retaining but little and evaporating a large amount.

The forest is the great reservoir of agricultural lands, giving up gradually throughout the season, when they are most needed by agriculture, its stores of the waters falling over its area. Rain and snow to a large extent penetrate the forest soil down to the impenetrable

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*Owing to the short time since methodical observations have been inaugurated (mainly in Germany), and the complicated nature of the investigation, the numerical data relating to forest influences are still exceedingly incomplete.

The most notable figures, so far more or less definitely established as general averages, are given as follows:

The temperature of the soil in the forest (always meaning a well-stocked dense growth) is lower than that of the open field; in spring, by 28 per cent.; in summer, by 24 per cent.; in autumn, by 16 per cent.; in winter, by 10 per cent.; in the average during the year, 21 per cent.

The temperature of forest air (interior) is lower than that of the fields, the difference being greater in proportion to elevation, and less in the region of the crown than nearer the ground. The difference in absolute temperature degrees is greatest in spring and summer, from 15 to 20 per cent.; in fall and winter the difference is small, the temperature in the forest being somewhat cooler during the day, but warmer during the night. On an average a reduction in temperature of 10 per cent. from that of the open field prevails during the year.

In the case of Kansas, for instance, this would mean a reduction in summer temperature of 10 to 15 degrees in a supposed forest, with all the consequences of reduced evaporation, cooler winds, and increased precipitation. The thermometrical range is from 5 to 20 degrees less in the forest than in the open, the greatest difference occurring in the hot months.

The relative humidity of the forest air has been found to be from 3 to 10 per cent., and in pine forests in summer as high as 13 per cent. greater than in the open. Observations in France place the difference at 1 to 3 per cent. in favor of deciduous, 7 to 13 per cent. in favor of pine forest, the greatest difference occurring in the summer months.

Evaporation in the field is greater by 57 per cent. in spring, 64 per cent. in summer and winter, and 66 per cent. in autumn.

Transpiration through the leaves during five months of vegetation, for a field with vegetable cover, has been estimated at 500,000 to 1,500,000 pounds of water per acre. Forest vegetation requires several times (probably three times) this amount.

Amount of precipitation over forest was found to be from $\frac{1}{4}$ to $1\frac{1}{2}$ inches (1.4 per cent.) greater in deciduous, and from $1\frac{3}{4}$ to $2\frac{3}{4}$ inches (8 per cent.) in evergreen forest. (These figures are probably too low.)

The amount of precipitation reaching the soil is dependent on the greater or less force of the rain, fine rain often being entirely intercepted by the crowns, while 80 to 90 per cent. of very heavy rain may reach the ground. When falling at the rate of $\frac{1}{4}$ inch in 24 hours, spruce forest intercepted 78 per cent., beech 27 per cent.; when at the rate of $\frac{1}{8}$ inch in 24 hours, spruce intercepted 95 per cent., beech 62 per cent. Yet observations in France through 11 years in a 40 to 57 year old beech forest show that only from 8.5 to 17 per cent. of the precipitation was intercepted. Last year's observation at the Prussian stations show the precipitation decreased under forest cover by 23 per cent.

subsoil, where the water accumulates and reappears elsewhere as springs; the less inclined the surface the more water penetrates, assisted by the deep and far-reaching ramifications of the roots and the permanent vegetable cover. While this beneficial action is especially noticeable in the mountainous regions, the forest of the plains also acts as a water reservoir; which will appear from the observed fact that in deforested localities the ground-water level has sunk and aridity is increasing.

Under the forest cover of the mountains the melting of snows is retarded, and thus the flow of streams is more gradual and continued evenly through a longer period. While the large floods are probably to a great extent due to cosmic causes, their aggravation through deforestation at the headwaters of streams cannot be denied; and that local floods, especially the ravages of mountain streams, can be obviated by proper forestry has been proved practically in France and the Tyrol within the last thirty or forty years.

The mechanical action of forest belts in breaking the force of winds, alleviating the effects of hot and cold blasts upon crops, and in ameliorating the severity of the climate of a neighboring district is well known to every prairie settler.

CLIMATIC INFLUENCE.

The influence claimed for forest areas upon the local climate of a neighboring region must be considered as mainly due to a difference of insolation and consequent difference of temperature and evaporation over the forest and the open field. This influence, therefore, is appreciable only when sufficiently large and dense forest areas alternate with open grounds.

In consequence of the difference between the temperature of the forest and that of the surrounding region, local currents of air are established, so that the forest acts like a large sheet of water as a starting-point for diverging local winds.

The cooler and generally moister air over the forest promotes the condensation of the lower layer of clouds and the condensible strata of air, so that, while the forest may not positively *cause* rain to fall, yet it does not at least prevent it, as the heated bare ground or field often does.

The climatic influence of the forest upon its neighborhood may be said to consist in the communication of its own climatic characteristics, *i. e.*, shorter range of thermometrical extremes and more permanent moisture in its atmosphere. These characteristics are more pronounced in summer than in winter; their degree is proportionate to the extent and density of the forest, and their communication to the surroundings is graduated by the distance from the forest. The forest, in short, is a regulator of climatic, as it is of hydrologic extremes.

Our present knowledge of forest influences, based on experiment, observations, and logical inferences, allows us to summarize the following facts:

A.—EFFECTS OF DEFORESTATION ON THE CLIMATE.

(*a*) *On the climate of the deforested area.*

(1) Extremes of temperature of air as well as of soil are aggravated.
(2) The average moisture of the air is lowered.
(3) Whether the moisture of the soil after deforestation will be greater or less depends on the nature of the soil.

(4) The total atmospheric precipitation is not necessarily diminished, unless clearing has been made over very extensive regions, but the distribution throughout the year will be disturbed; the amount, however, which reaches the soil is largely increased.

(b) *On the climate of the surrounding country.*

(1) The areas that were situated near the forest lose their protection against drying and cold winds.

(2) The force of the winds is unbroken; a change more detrimental where the configuration of the ground does not fulfill a similar function, in large plains more than in hilly and mountainous regions, and at the sea coast more than in the interior.

(3) The unfavorable consequences of deforestation are more marked the more the climate of a locality has a continental character, and the less marked the more it approaches the character of a coast-climate.*

B.—Effects of deforestation on water supply.

(1) After deforestation the soil is deprived of very much less water by the process of vegetation than before.

(2) Where a superfluity of moisture used to be removed by this process, deforestation often induces a formation of marshes, and, in consequence, unfavorable sanitary influences on the surroundings are possible.

(3) In consequence of deforestation, evaporation from the soil is augmented and accelerated, resulting in an unfavorable influence on soil humidity and on the size and continuity of springs.

(4) With the disappearance of the forest the retarding influence of soil cover and of trunks on the superficial flow of water ceases.

(5) This circumstance, in conjunction with the augmented evaporation from the superficial springs and rivulets and from the soil, causes the unfavorable influence of deforestation on the flow of brooks and rivers.

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* From this it will at once appear how futile must be the attempts to name a certain percentage of forest cover as necessary for a country to preserve favorable climatic and hydrologic conditions, and another percentage for the requirements of raw material. As the latter must depend upon the number of inhabitants, the productiveness of the forest, and several other variable factors, so does the former depend on conditions the bearing of each of which we have not yet been able to calculate; it must certainly vary according to geographical location and configuration of soil. England, with its moist and cloudy climate, in a temperate zone, can well dispense with a large per centage of forest cover—it has only 3.23 per cent.—while poor thirsty Spain suffers from drought with 16.30 per cent. of forest, and Austria, on account of the configuration and character of her territory and the great number of water-sheds, feels the need of more than 30 per cent. of forest cover. For a country like the United States it is impossible to pronounce upon a required forest area for climatic reasons, as its parts must so widely differ in this, that no meaning could be attached to any percentage expressed for the total. (See table on page 185.) From the table on page 169, on which the percentage of forest cover in different sections is noted, it will appear that, if the forest areas exist as reported, it can hardly be said that the percentage of forest is dangerously out of proportion on the Atlantic coast, the Gulf States, or even the Central and the lake-surrounding Northern lumbering States; on the other hand, the Western agricultural, prairie, and mountain regions appear decidedly deficient. While, therefore, local hardships, due to injudicious clearing of hillsides, may be brought about in the first-mentioned sections, the climatic aspect of the forestry problem concerns most nearly and immediately the central and western half of the country, where a continental climate and the interference of high mountain ranges with moisture-laden winds, call most strongly for the modifying influence of the forest.

(6) How much and to what extent the forest cover contributes to regulate the amount of precipitation over a given area or the flow of water through a given period of time, so as to prevent or ameliorate floods and droughts, in opposition to disturbing causes, cosmic or produced by human agency, cannot yet be stated, though the existence of such influence is sufficiently proved.

C.—EFFECTS OF DEFORESTATION ON THE CONDITION OF THE SOIL.

(1) In the mountains deforestation causes torrents, carrying débris into the valleys; land-slides, snow-slides, and avalanches are induced more or less, according to the profile and nature of the rocks.

(2) On light sandy soil, especially near the coast, where winds are strongest, the shifting of sands and formation of dunes is facilitated.

The importance of considering these influences is greatest for the western half of the United States, especially for the exposed prairie regions and the arid and semi-arid districts, which depend largely for their agricultural development on the water supply from the adjacent mountains, and also in Southern California and in the Rocky Mountain States and Territories.

Common interest and the simplest prudence demand the preservation of these mountain forests in perpetuity under most conservative management.

Less urgent, but not to be underestimated, is the weight of these considerations for the eastern half of the country, notably the coast lines and the Alleghany Mountain ranges.

CONDITION OF FOREST SUPPLIES AND FORESTRY IN THE UNITED STATES.

The forest area of the whole United States, excepting Alaska, at the present time has been reported by the Forestry Division as less than 500,000,000 acres (489,280,000).

There is reason to believe that much of this area is waste brushland, and that even the timber forest often hardly deserves the name, being only thinly stocked with trees.

Leaving out of consideration the forests of the Pacific slope, estimated at 60,000,000 acres, and said, though little known, to cut large amounts per acre, the balance of forest land in the United States, it is believed, cannot long meet the enormous demands on its resources.

No reliable statistics exist from which the stock on hand could be even approximately computed for the whole extent; but we do know tolerably well the quantity of lumber and wood annually used or required by our present population. In round numbers this amounts to something like 20,000,000,000 cubic feet, made up of the following items:

	Cubic feet.
Lumber market and manufactures	*2,500,000,000
Railroad construction	†360,000,000
Charcoal	†250,000,000
Fences	‡500,000,000
Fuel	§17,500,000,000

* Computed from figures of the Bureau of Statistics.
† Latest estimates of the Forestry Division.
‡ Computed on the basis of a careful investigation by the Department in 1871.
§ Computed on the basis of census statistics of 1880.

There is also to be added an item requiring yearly a considerable amount of wood for a use to which no other civilized nation puts its forests. I refer to the 10,000,000 acres or so of woodland burnt over every year, intentionally and unintentionally, by which a large amount of timber is killed or made useless; and, what is worse, not only is the young growth destroyed by these fires, but the capacity of the soil for tree-growth is diminished, as they destroy the beneficial physical qualities of the leaf-mold; and if occurring on recent clearings, inferior kinds of timber, capable of thriving under the altered conditions, occupy the ground and diminish the value of the area.

The present reckless method of turpentine-orcharding also deteriorates large quantities of timber unnecessarily.

The wasteful methods which are employed in lumbering, especially by the tie-cutter,* often avoidable without financial loss to the lumberer, hasten the reduction of visible supplies.

What amount of forest products will be required by the country by the next centennial it is idle to attempt to compute; that it must increase with the growing population and development is self-evident, and that, too, in spite of substitutes for wood in many branches of industry.†

AREA REQUIRED.

So far we have lived upon our forest resources without considering whether we were using up the interest or the capital.

Assuming that we shall need a continuous supply of only the 20,000,000,000 cubic feet computed above, it would be of interest to ask what area in forest will be required to furnish the amount continuously.

With our present knowledge there is no possibility of calculating the average yearly growth that can be expected upon the entire present forest area of the United States. While I am inclined to think that the capacities of the soil, climate, and indigenous species of our country are greater than those of Europe, yet in their present condition our forests do not compare favorably in regard to annual yield with the well-cared-for and well-stocked continental forest areas.

The average yearly accretion per acre in German forests has been computed at 50 cubic feet, or on every 100 cubic feet of standing timber 2.3 cubic feet of new wood yearly. Applying these figures to our present requirements, and assuming as close a use of material as is the European practice, it would appear that an area of not less than 400,000,000 acres must be kept in well-stocked forest to give us a continual supply for our present needs.

We are nearing therefore, (if we have not yet reached), the time when increased drain means a squandering of capital, and a time when regard to the husbanding and the careful management of our forests is required for the purpose merely of furnishing raw material. This fact will appear still more clearly if we inquire into the supply of certain

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*It is computed that in the California redwood forests to produce a railroad-tie worth 35 cents timber to the value of $1.87 is wasted.

†It is significant to note that other nations are aware of our deplorable condition in regard to future forest supplies. The Government of Bavaria last year sent an expert forester to study the timbers of the United States, who explained the purpose of his mission in these words: "In fifty years you will have to import your timber, and as you will probably have a preference for American kinds, we shall now begin to grow them, in order to be ready to send them to you at the proper time."

kinds of timber. Numerous expressions in regard to the growing scarcity of desirable hard-wood supplies for manufacturers will be found in the report of this Department on the exhibit of wood manufactures at the New Orleans Exposition. No better indication of the state of forest supplies can be given than the trade reports in lumber papers.

As the accuracy of the statistics and estimates in Government reports has been questioned and their value doubted, it may be of interest to publish the following extracts from a letter recently received from Mr. G. W. Hotchkiss, for many years Secretary of the Lumbermen's Exchange at Chicago, recognized as an authority in lumber statistics.

He says:

So far as White Pine (*Pinus strobus*) is concerned, it occupies to-day a position in forestry analogous to the Indian in the body politic, practically a thing of the past. Of course there are sections which will last for many years (not so very many either), but the great bulk is gone, and, like the straggling tribes, but a remnant of former strength and power remains, and but a few decades more and they will be known only in history as a thing of the past. One hundred years ago Maine, Vermont, New Hampshire, New York, and Pennsylvania could boast vast forests of White Pine. West of the lakes, Michigan, Wisconsin, and Minnesota, so late as fifty years ago, were unbroken in forest resources, and the White Pine predominated. To-day Maine gives us some spruce and a little small sapling pine, such as would hardly have been sent for firewood in her palmy days of lumbering. Vermont, New Hampshire, and New York may still boast an occasional clump of trees, but have lost all pretensions as lumber-producing regions. Pennsylvania has a few hundred million feet on the sides of the Alleghanies, but has dropped out of the list as a lumber producer. East of the great lakes nought remains (excepting the spruce forests of Northern and Eastern Maine) save hemlock and hard wood, and these in very limited quantities, insufficient to supply the home demand in a majority of localities. Michigan, Wisconsin, and Minnesota are the last remaining resorts for lumbermen east of the Rocky Mountains. Originally there was probably 150,000,000,000 feet B. M. in Michigan, but fifty years' work has reduced the supply to probably not over twelve to twenty billion feet, with an annual average cut for the past five years of not far from four and a half billions; and the cutting is so close as to exterminate all the pine timber on the tract operated upon. Wisconsin can hardly be estimated at over thirty to thirty-five billion, little more than would suffice to supply the consumption of the United States as a whole for one year. Minnesota, set down in the census of 1880 as having 11,000,000,000 feet B. M., an amount disputed by some as too high, by others as too low, if allowed to-day at 10,000,000,000, could furnish but one year's supply for the mills of the Northwestern pine-producing States. In fact, if the mills of these three States were run to their capacity for six years there would be but little pine left for the seventh year's production. And these estimates of timber include the red or Norway pine, which forms a noticeable percentage of the whole. In Michigan and Wisconsin there are still large quantities of hard wood, but it is not being cared for with that appreciation of its value which is desirable. It has, however, this advantage, it can be reproduced. Pine cannot.* The future timber supply of the East must be largely from the hard woods. The vast forests of the Pacific slope will supplement this with such soft lumber as may be needed. Before many years the forests of Alaska will swarm with enterprising timber seekers. Already those of California, Oregon, and Washington Territory have been the subject of research, and vast amounts of Eastern capital are already invested there. British Columbia, west of the mountains, will supplement the supply, but our children will bring their pine and fir from Alaska. Meantime the supply east of the Rockies once denuded will be known no more, except through wise Government action in protecting and encouraging timber culture. Our present laws in this respect, so far as they relate to taking up land, are a farce, falling little short of tragedy, as the Government parts with the land without accomplishing the purpose of the grant in one case in a hundred, until it has lost control of all sufficient areas, which might be made a blessing to our successors in life's race.

I have not for some years given the subject of Southern production so much

*This can mean only reproduction from the stock. Reproduction of White Pine from seed is as easily effected as that of any other conifer, but of course requires special management, as will be outlined further on in this report. B. E. F.

thought, so far as statistics are concerned, and can speak only generally. There has been a great impetus to trade in the South during the past five years. You will be safe in computing the consumption of all kinds of wood at 500 feet per capita of the population, and at 8,000 feet per acre, it would take about 4,000,000 acres per year for its supply. In Southern timber both the Long-leaved and Loblolly Pine grow and can be reproduced in their native soil, so that the statement above that "pine does not reproduce itself" applies only to the White Pine of the North. I know of no good reason why Government endeavors to foster and perpetuate large areas in the South would not be eminently successful. But it should not be delayed, as the wastefulness which has brought the White Pine resources of the North so near to their extinction is rapidly doing the same for the Long-leaved and Loblolly of the South. It is to me a source of surprise that some of the lumbermen of the country, men who are or have been for scores of years tramping through the forests, are but now awakening to a perception of the true condition of our forests. That they have opened their eyes to the truth is made evident to those who, like myself, are in position to know of the search which is being made for desirable bodies of timber, by men who six years ago set down the Government estimates and statements as veriest bosh, and loudly asserted that no diminution in present annual supplies would be seen for a generation to come.

BUILDING MATERIAL.

A most unbusiness-like manner of calculating has been practised in order to ascertain how long the Pine timber supply may be expected to last in the several States at the present rate of cutting, as if each State were surrounded by a Chinese wall or a prohibitory export tariff. Evidently we can come to practical conclusions only by calculating for the country as a whole, and by keeping in view the aggregate supplies of at least the White Pine, Spruce, Hemlock, and Southern Pine areas and the demand upon them; as practically they are used interchangeably and in the future will be still more so to fill our immense requirements for building material, other soft woods like Whitewood, &c., supplying only a small addition.

Taking the estimates of the census of 1880 as a basis, and, to avoid any danger of an underestimate, adding one-third to the amount of the above-named timbers reported as standing, we find that in round numbers 600,000,000,000 feet B. M. might be considered then standing to supply a yearly demand of not less than 12,000,000,000 feet, making the exhaustion of Eastern-grown building timber supplies appear reasonably certain within the next fifty years.

That the additional supplies of Redwood and other Pacific coast timbers will hardly compensate for timber destroyed by fire, as well as for the drafts on Northern Hemlock for tan-bark and on Southern Pine for turpentine orcharding, and for the additional requirements of the growing population, may also be confidently asserted.

However much these calculations may differ from the actual state of affairs, they are sufficiently near to call for more than a passing consideration on the part of those who have any interest in the future welfare of the country.

The second growth of White Pine, pointed out as coming to use in the New England States, is cut mostly when only fit for boxboards, and will not figure much in the great market for building materials. It may be mentioned here that, according to experiments made in Germany on Scotch and White Pine, the requisite quality for building purposes which the Scotch Pine attains in seventy years is hardly attained in ninety years by the White Pine, while, according to Dr. Mohr, the Long-leafed Pine requires two hundred years' growth to furnish timber of good quality. The new spontaneous growth of this class of material, left to Nature's kind but slow methods

of providing for it, is infinitesimal when compared with the needed supply.

The hard-wood forests, though in some localities diminished beyond desirable proportions, owing to their natural reproductive power are in less danger of extinction, or even of deterioration, than the more useful, more necessary, and at the same time less easily reproduced pine forests. Yet even in regard to these, complaints of the deficiency of suitable supplies for manufactures are plentiful.

The enormous yield of the forests on the Pacific slope, though probably overstated for average amounts, will perhaps furnish timber for many decades; but attacked under the same conditions as the once "inexhaustible" timber areas of the Northwest, and under the same methods of treatment, we cannot expect better results than we have witnessed in connection with these Northwestern forests.

Of the Rocky Mountain forest area as a whole not much can be expected in regard to lumber supply, except for local purposes. But the existence of these forests on the mountain-sides serves a much more important purpose in holding snow and water for the use of the agricultural lands below during the dry seasons to which they are liable, and in preventing or lessening torrential action. A large part of the forests of Southern California and of other mountainous regions belong to the same category (important chiefly on account of their position), and should be managed and utilized with a view to the best interests of the lower agricultural lands.

IMPORTS AND EXPORTS.

The following tables are compiled mostly from the reports of the Bureau of Statistics of the Treasury Department. An indefinite amount of wood in manufactured articles not enumerated would increase these amounts.

The imports of forest products from Canada form naturally the bulk of our importation, amounting to $9,355,736 for the year ending June 30, 1885, equal, perhaps, to round 75,000,000 cubic feet. Almost the entire cut of the Province of Ontario, amounting in value to $7,371,028 for the year 1884, comes to the United States. This shows that the duty of $2 a thousand feet does not prevent competition, and also that from its abolition little hope is to be drawn for the preservation of our resources. In Canada there can be little doubt that all the possibilities of production are even now strained to the utmost.* The exportation of forest products from Canada used to go entirely to Great Britain and the West Indies; but since the pine lands of the Northwestern States have become gradually depleted, Canadians have successfully competed with the lumbermen of Michigan and Wisconsin, till to-day their exports to Great Britain and the United States are almost equal in amount. The expressions of the Hon. H. G. Joly, member of the Dominion Council of Agriculture, show that the visible supplies of white pine in Canada are almost in the same deplorable condition as those in the United States, and that the prospect of supplying our needs by importations from Canada is altogether not very encouraging.

* For the year ending June 30, 1886, the trade and navigation returns of the Dominion show the total exportation of forest products from Canada to the United States as amounting to $8,500,000, or 40 per cent. of the total lumber export. Ontario exporting to this country to the value of $6,500,000; Quebec, $1,300,000; Nova Scotia, $270,000; New Brunswick, $438,000.

Imports for consumption, of wood and wood products, 1883 *to* 1886.

Articles.	1883–'84.			1884–'85.			1885–'86.		
	Quantities.	Cubic feet.	Value.	Quantities.	Cubic feet.	Value.	Quantities.	Cubic feet.	Value.
Free of duty.									
Wood, unmanufactured, not elsewhere specified:									
Fire wood .... cords..	169,269	16,249,824	$373,911	162,471	15,597,216	$338,806	176,150	16,910,400	$349,135
Logs and round timber	....	5,617,300	449,382	....	4,811,800	384,948	....	5,748,000	459,843
Railroad-ties .... number..	1,932,674	6,764,359	382,719	1,100,086	3,850,301	187,168	2,075,910	7,265,301	377,443
Shingle and stave-bolts	....	2,483,420	243,342	....	1,211,770	121,177	....	1,343,570	134,357
Ship-timber	....	190,016	47,504	....	58,652	14,663	....	156,076	39,019
Ship-planking	....	125,829	41,943	....	66,369	22,123	....	56,571	18,857
Hop-poles	....	323,200	40,399	....	150,200	18,780	....	100,000	12,511
Wood-pulp	....	....	5,941	....	....	9,637	....	....	5,897
Charcoal .... tons..	7,085	....	56,765	5,610	....	47,334	4,542	....	36,849
Cabinet woods:									
Box	....	....	83,921	....	....	223,015	....	....	72,403
Cedar	....	....	568,896	....	....	520,605	....	....	520,184
Ebony	....	....	63,074	....	....	26,311	....	....	69,043
Granadilla	....	....	265	....	....	432	....	....	2,807
Lancewood	....	....	7,951	....	....	1,117	....	....	16,910
Lignum-vitæ	....	....	45,266	....	....	8,698	....	....	42,362
Mahogany	....	....	772,710	....	....	592,771	....	....	479,861
Rose	....	....	157,266	....	....	52,306	....	....	46,957
Sandal	....	....	4,009	....	....	654	....	....	2,598
Satin	....	....	5,834	....	....	5,984	....	....	12,641
All other cabinet woods	....	....	315,173	....	....	226,491	....	....	219,585
Cork wood or bark, unmanufactured	....	....	935,871	....	....	879,243	....	....	891,392
Hemlock bark .... cords..	68,070	....	364,410	59,020	....	288,979	50,314	....	236,198
Total, free of duty	....	31,723,948	4,971,202	....	25,746,308	3,971,242	....	31,579,918	4,046,852
Dutiable.									
Wood, unmanufactured, not elsewhere specified	....	674,700	80,961	....	324,700	38,960	....	215,200	25,827
Timber	....	71,812	8,512	....	73,290	11,712	....	75,794	12,221
Lumber:									
Boards, planks, deals, &c. .... M feet..	536,712	44,547,096	6,987,694	502,250	41,686,750	6,189,781	479,207	39,774,181	5,639,813
Clapboards .... M..	1,512	250,992	28,786	2,996	497,336	41,827	3,910	649,060	59,389
Hubs, posts, lasts, and rough blocks	....	....	60,690	....	....	59,039	....	....	60,615
Laths .... M..	186,424	3,728,480	257,529	154,813	3,096,260	199,819	153,575	3,071,500	198,756
Pickets and palings .... M..	4,699	375,920	57,596	4,699	375,920	51,027	5,076	406,080	61,318
Shingles .... M..	86,163	1,196,708	215,454	69,754	968,806	158,043	79,101	1,098,625	171,523
Shooks	....	336,264	84,066	....	280,060	70,015	....	421,796	105,449
Staves	....	1,120,600	280,150	....	1,014,812	253,703	....	1,079,844	269,961

Imports for consumption, of wood and wood products, 1883 *to* 1886—Continued.

Articles.	1883–'84.			1884–'85.			1885–'86.		
	Quantities.	Cubic feet.	Value.	Quantities.	Cubic feet.	Value.	Quantities.	Cubic feet.	Value.
Dutiable—Continued.									
Manufactures:									
Casks and barrels	....		$1,896	....		$1,494	....		$1,224
Cabinet-ware and furniture	....		295,064	....		268,700	....		308,088
Osiers and willows, peeled and dried	....	1,590,521	51,691	....	1,411,842	28,665	....	1,378,499	15,164
Osier and willow baskets, &c	....		237,834	....		202,262	....		233,380
All other manufactures	....		607,007	....		557,305	....		462,809
Bark extracts, chiefly hemlock, for tanning ... pounds	1,908,140	....	31,686	964,956	....	19,656	463,536	....	9,273
Sumac ... do	18,221,271	....	668,440	14,959,944	....	504,289	18,258,771	....	564,672
Cork and cork bark, manufactured	....	....	158,419	....	....	147,132	....	....	176,678
Walking-sticks	....	....	14,560	....	....	11,628	....	....	9,079
Matches	....	62,843	348,055	....	19,210	106,395	....	6,172	34,187
Total, dutiable	....	53,955,936	10,456,090	....	49,748,948	8,921,452	....	48,176,751	8,424,426
Total, free and dutiable	....	85,709,884 +	15,427,292	....	75,495,256 +	12,892,694	....	79,756,669 +	12,471,278

Exports of wood and wood products from the United States from June 30, 1883, to June 30, 1886.

Articles.	1883–'84.			1884–'85.			1885–'86.		
	Quantity.	Cubic feet.	Value.	Quantity.	Cubic feet.	Value.	Quantity.	Cubic feet.	Value.
Fire-wood ....cords..	2,646	254,016	$9,464	2,181	209,376	$6,985	2,723	261,408	$8,568
Boards, deals, and planks ....M feet..	414,920	34,438,360	7,079,701	412,424	34,231,192	6,570,576	435,608	36,155,464	6,620,911
Joists and scantling..........do....	12,632	1,048,456	195,043	13,028	1,081,324	183,166	10,821	898,143	151,119
Hoops and hoop-poles..........number..	29,706,000	4,455,900	356,470	28,883,000	4,332,450	346,598	18,699,000	2,804,850	224,385
Laths..........M..	9,180	153,000	22,295	9,517	158,617	20,277	17,825	295,895	48,377
Palings, pickets, and bed-slats..........M..	1,577	114,540	15,615	2,408	174,881	28,515	2,074	150,645	19,544
Shingles..........M..	61,962	*857,141	183,521	45,867	637,042	132,976	42,072	581,996	103,049
Shooks, box..........M..	....	653,985	186,853	....	720,426	205,836	....	604,498	174,723
Shooks, other..........number..	1,275,450	4,579,311	1,526,437	1,281,571	4,396,395	1,465,465	1,098,347	3,295,041	1,198,444
Staves and headings..........do....	134,324,000	40,297,200	2,686,473	97,537,000	29,261,100	1,950,744	101,505,000	30,451,500	2,030,097
All other lumber	....	8,135,000	976,191	....	9,841,200	1,182,143	....	9,792,500	1,175,099
Timber, sawed ....M feet..	201,257	16,704,331	2,247,328	153,248	12,770,667	1,609,485	193,344	16,112,000	2,092,557
Timber, hewed ....cubic feet..	....	10,615,065	1,735,382	....	8,411,066	1,289,281	....	5,037,612	829,019
Logs and other timber..........	....	21,307,900	1,704,635	....	21,147,200	1,691,780	....	15,732,100	1,258,575
Total unmanufactured	....	143,614,205	18,925,408	....	127,372,936	16,683,827	....	122,173,652	16,014,467
Manufactures of—									
Doors, sash, and blinds..........	....		294,942	....		284,016	....		267,005
Moldings, trimmings, &c..........	....		173,661	....		131,403	....		104,935
Hogsheads and barrels, empty	....	*6,954,636	320,184	....	*6,214,644	324,206	....	*6,089,977	497,458
Household furniture	....		2,429,831	....		2,128,692	....		2,121,812
Wooden-ware	....		406,264	....		321,464	....		331,235
All other manufactures	....		1,724,838	....		1,590,714	....		1,386,398
Total manufactures	....	6,954,636	5,349,720	....	6,214,644	4,780,495	....	6,089,977	4,708,843
Naval stores:									
Rosin ....barrels..	1,545,211	....	2,909,074	1,269,304	....	2,198,267	1,131,560	....	1,963,091
Tar ....do....	43,544	....	91,284	37,572	....	66,449	19,068	....	36,208
Turpentine and pitch ....do....	53,259	....	118,842	16,178	....	29,847	13,297	....	32,999
Spirits of turpentine..........gallons..	11,300,729	....	3,885,500	8,987,226	....	2,690,231	8,217,678	....	2,811,777
Total naval stores	....	....	7,004,700	....	....	4,984,794	....	....	4,844,075
Bark and tanning extracts	....	....	292,851	....	....	346,218	....	....	283,086
Sumac ....pounds..	....	....	....	....	....	....	320	....	13
Matches	....	40,272	106,809	....	27,936	69,840	....	34,250	82,204
Agricultural implements	....	....	3,442,767	....	....	2,561,602	....	....	2,367,258
Sewing-machines	....	....	3,552,814	....	....	2,898,698	....	103,388	2,584,717
Musical instruments..........number..	9,888	....	1,079,118	9,609	....	941,344	9,305	....	871,446
Miscellaneous values..........	....	....	7,474,359	....	....	6,817,702	....	....	6,188,724
Aggregate quantities and values..........	....	150,609,113	38,754,187	....	127,615,516	33,266,818	....	128,401,267	31,756,109

*Estimated.

GOVERNMENT TIMBER LAND.

In 1883 the area of timber-land remaining in the hands of the General Government was estimated in round figures at 73,000,000 acres, (probably an underestimate). The greater part of this is situated in the mountain regions of the West. Neither its condition nor its exact extent and location are ascertainable from the records of the General Land Office, no efforts having been made to note sufficiently the condition of the public domain when surveys were platted. No attempts are made at forestry management, and in the disposal of land no adequate distinction is made with a view to aiding in the development and settlement of the country.

The efforts to prevent depredations, amounting yearly to many million dollars, are mostly frustrated for lack of means or organization. The laws relating to the protection of the forest domain are either inadequate, or ineffective for want of execution. This is often made practically impossible by the existence of "servitudes" or privileges like those which hamper the forest administrations of Europe, *i. e.*, rights of certain corporations or persons to cut timber on the public domain for specified uses, such as railway construction, mining operations, charcoal burning, domestic use, &c.. These privileges were granted by the Government to stimulate and aid development, but their abuse causes continued depredation on this valuable property of the people.

The General Government should of course protect such public property until disposed of, as well as any private owner would protect his own, and should dispose of it only to subserve the fundamental idea of our land policy, in the development of the country.

But from the foregoing exposition it would appear that a broader consideration of this property, a more distinct policy in regard to it, should prevail than the mere consideration of the best manner of parting with it.

It may be confidently asserted that—

(1) The remaining public timber domain would not be best disposed of by sale, nor is it needed for settlement.

(2) It is principally more valuable for the timber on it than for agricultural purposes.

(3) It is likewise more valuable, by its position on mountain slopes and crests, for other objects than for its material.

(4) Its retention and administration, under Government control, is demanded by the best interests of the adjoining territories as well as of the country at large.

Though it cannot be expected that, by the withdrawal of such lands from sale and their administration by the Government, much will be contributed towards warding off scarcity in the lumber supply of the future, the area being insignificant, it would to some extent tend toward accelerating a wholesome change in the methods of the lumber industry, curtailing the area for speculative enterprises. The lands thus reserved would form a nucleus and an example for American forestry, making possible the organization and economical working of a Forestry Department, to which we must ultimately come. The necessity of such Government forestry has been ably discussed in a report to this Division by Mr. E. J. James, professor of economics in the University of Pennsylvania. But most of the forest area remaining in the hands of the Government is of greater importance for

the purpose of preserving intact the headwaters of mountain streams and regulating their flow than for the timber on it.

Inquiry into the experiences of settlers on the eastern slope of the Colorado mountain range, where the supply of water for irrigation ditches is a necessity for agricultural pursuits, and where, therefore, special attention is paid to water-flow, reveals the fact, that many mountain streams which used to have a constant, more or less even flow, have at times given place to dry beds, while at other seasons precipitating a torrential mass of water into the plain below. In Greeley and its surroundings the deficiency of water in the irrigation ditches has become alarmingly serious, and the cattle interest all along the mountain ranges begins to experience the inconvenience of diminished watering facilities, going hand in hand with the destruction by fire and ax of the forest cover on the adjacent mountains. From reliable sources of information we hear of similar complaints in Southern California.

The safety of water-reservoirs, which by engineers are considered the ultimate requirement for the development of the agricultural possibilities of these regions, whatever we may think of the practicability of such storage systems, will be subserved by securing a more gradual and less destructive discharge of atmospheric precipitations into the reservoirs, a result naturally produced by the spongy forest cover. Nor should it be overlooked that the water slowly draining through moss and vegetable mold carries with it for the use of agricultural crops no mean amount of fertilizing matter.

In regard to the relation of forest destruction to water-flow and agricultural deterioration we might again cite the often-repeated experience of older nations in Asia and Europe; but as the conditions in our country differ in important particulars from those prevailing elsewhere, exception to inferences drawn from that source might reasonably be taken.

While—thanks to our more favorable conditions of configuration and our less closely worked soil—we are by no means anywhere near such conditions of devastation as those experienced by Southern France, Switzerland, and the Tyrol, where, to preserve the agricultural lands below from devastation by water, many million dollars have been expended, and are still expended yearly, for the costly building of dams and for difficult reforestation, yet such conditions are merely dependent upon time and continued negligence; and we had better decide now whether the policy of unconcern shall be abandoned, and whether by simple protection and preservation of the existing forest cover great loss and the expenditure of millions in the future shall be saved to the nation. That such important interests may safely be intrusted to the care of the private individual, whose life is short and whose concern is for to-day, nobody can reasonably assert. That such use of the forest can be secured only if kept in the hands of the whole nation (*i. e.*, the General Government or the individual State governments) lies in the nature of things, as the State alone will be found capable of managing a large property for other purposes than to realize its direct money value. The objection of expense raised against such measures as have been proposed for the preservation and protection of Government timber lands is frivolous in view of the magnitude of the interests at stake, and the practicability of organizing a service to prevent spoliation of these forests and to manage them as shelter forests in the interest of the regions in which they are situated, may be made apparent by a sketch of such an organization in detail.

PLAN FOR A FOREST DEPARTMENT.

I may be allowed to quote here from a letter recently written by me on this subject at the request of a special agent of the Department of the Interior:

* * * As preliminary to the discussion of what should be the policy of the General Government, allow me to state a few points of forestry which must be understood:

(1) Not more than what grows yearly or during certain periods should be cut in a forest which is to be kept in perpetuity.

(2) No clearing, unless followed by immediate planting, is admissible in mountain forests; nor is it advisable in the plain.

(3) The cutting of timber must be done with a view of renewal above all other considerations. The method, time, and duration of cutting over a given tract depend upon the kind of timber and the locality. To be continually successful in keeping a desirable forest cover requires more care than the simple method of selection practised by the lumbermen.

(4) What the average yearly accretion in the forests of the public domain amounts to is still more uncertain than their extent. Assuming that the 70,000,000 acres probably owned by the Government produce yearly, at an average, only 10 cubic feet per acre, which by correct management could in a short time be doubled, and reckoning 1 cent per cubic foot on the stump as a low estimate, the domain at present represents a capital of at least $280,000,000. The annual expenditure for the preservation and improvement of such property of a sum equal to the value represented by the annual growth may not be considered extravagant. To this add the larger part of $8,000,000, the value of timber destroyed by fires, which would probably be prevented by proper organization.* If, therefore, the importance of these mountain forests did not justify a larger expenditure annually upon their preservation, the application of the value of their annual product for their protection and management would be admissible simply from a business point of view.

The following features in the organization of the public timber domain appear desirable and practicable:

(1) To withdraw from sale or other disposal all timber lands.

(2) If the expense of a survey—a simple running of outside boundaries—appears too great to warrant such survey, the withdrawal may be gradually effected by a process of exclusion whenever entries for land are made. The exact location, too, may be established gradually from the notes of local land offices and the observations of the forest guards, as hereinafter suggested. But in the more settled districts a boundary survey at least will soon become necessary.

(3) The organization of the service should include a central bureau, traveling and local inspectors, and forest guards.

(4) The organization of the forest area should proceed gradually, as required, by dividing it into reserves of ten to twenty thousand acres each, twenty to thirty of such reserves to be formed into a district, the size and number of reserves and districts to be dependent on local needs and the greater or less difficulty of inspection. Unorganized territory to be divided into districts only.

(5) Functions of officers:

The rangers, or forest guards, act as local police, under general instructions and regulations from the central bureau, and under direct supervision of local inspectors, to whom they are responsible for their reserves and upon whose recommendations they should be appointed. Assistants may be required during the dangerous season, and sheriff's power to call upon the aid of any citizen should be conferred upon these.

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*The acres burned over and values destroyed during the census year 1880 were reported as follows:

States and Territories.	Acres.	Value.	States and Territories.	Acres.	Value.
California	356,895	$440,750	Wyoming	83,780	$3,255,000
Washington	37,910	713,200	Nevada	8,710	19,000
Oregon	132,320	593,850	Utah	42,865	1,042,800
			Colorado	113,820	935,500
Total Pacific slope	527,045	1,747,800	Arizona	10,240	56,000
Montana	88,020	1,128,000	New Mexico	64,034	142,075
Idaho	21,000	202,000	Total Rocky Mountains.	432,464	6,780,371

The district inspectors, who must live within their district, appointed upon recommendation of the chief of division, and placed under bonds, are responsible for their districts and the acts of their rangers, and report to and advise with the central bureau; they superintend and regulate in detail the cutting of timber and other necessary or prescribed work, see to the execution and observance of laws and regulations, and act as intermediaries between the public and the central bureau.

The central bureau, under a commissioner, with three division inspectors or chiefs of division, as a council, makes the regulations for district inspectors and rangers, has disposition of the funds, according to the yearly budget, fixes price and conditions for the sale of timber, and grants privileges from year to year, determines manner, method, and time of cutting, &c., and, in connection with the Land Office, prepares the mapping of districts and the legal work.

The chiefs of division ought at least once a year to make an inspection tour over their division, composed of a number of districts, and so laid together as to facilitate their inspection. One for the Pacific slope, one for the Rocky Mountain region, and one for all other timber lands might suffice in the beginning.

(6) The disposal of timber to be cut under the regulations of the central bureau, with a view to natural reforestation, should be made on the stump, and in the first place for the requirements of the local demand only.

The localities and areas to be cut over, also the lowest selling price for timber, if even only nominal, must be established yearly upon the report of the district inspectors as to applications and local requirements, revised by the chief of division; so that in proper season the places where cutting will be allowed, the conditions of sale and other regulations, the Government rate, &c., can be advertised, and at stated days in each district, the timber may be disposed of at public auction to the highest bidder, who must deposit the amount of his bid with the central bureau before cutting. Where local supply is the main object of such sales, they should be in small parcels to suit. Where lumbering is to be considered above local need, larger parcels may be disposed of.

Permission to erect saw-mills, &c., should in every case emanate from the central bureau, which acts as the administrator of a valuable property, and should be given the greatest latitude in the division of the territory, the use of its forces, and in arranging for the co-operation of local and State authorities. Such an organization would require, besides the head of the bureau, only three thoroughly trained foresters as chiefs of divisions. The district inspectors are best chosen from men conversant with lumbering operations and woodcraft and with some knowledge of and interest in forestry. The guards may be simply reliable men of discretion.

(7) The cost of the total service depends of course on the number of districts to be formed. Take Colorado alone, which we will assume contains about 5,000,000 acres of public domain; for this we may require three hundred rangers and ten inspectors, and the expense may be placed in round figures at $300,000. This amount could be saved by preventing only one-third of the forest fires, which seem to destroy over $900,000 worth of public property in that State yearly, and the 50,000,000 cubic feet or so of timber, which may be cut to satisfy the needs of the country for its development, would certainly, without hardship to any one, yield enough to help pay the expense of less favorable localities and of the central bureau. The expense of the latter, with the necessary staff of clerks, &c., could certainly be kept within the sum of $50,000. Even if the whole forest area were as thoroughly organized as proposed for Colorado, the expense of the service would not be more than 30 per cent. of the income which might be derived from this domain, or, which could be saved, by preventing one-half of the fires that yearly destroy about an equal amount.

Thus the matter of cost appears as nothing. But I repeat that if the total income from the domain were spent upon its preservation and improvement it would not be an extravagance, and future generations of farmers, miners, builders, nay, of lumbermen, would extol the wisdom of the legislature which thus preserved the needful forest cover of the mountains.—B. E. F.

GOVERNMENT PLANTATIONS.

That the operations of such a forest department might be properly extended to the creation of new forests, so as to produce beneficial effects upon the agricultural conditions of the arid and semi-arid regions of the Western States and Territories, suggests itself. It has been shown that the climatic influences of the forest must be largely dependent upon its size and density, therefore no considerable change of the unfavorable climatic conditions of the plains can be soon

expected, unless large tracts be covered with forest growth. The military reservations in the hands of the General Government form a most desirable basis for such extensive plantations. Covered with a dense tree growth, such oases in this bleak but fertile "desert" would better subserve the objects of our land policy in regard to the development of the country than the disposal of them directly to settlers.

If properly managed such Government forests would serve most admirably as practical schools of forestry, as object lessons, as forest experiment stations, and would afford aid where most needed to the forest planter of the plain, an example and incentive worth more than any other appropriations or grants in behalf of forestry which the Government could make.

It is *not* the control of the Government over private property, it is *not* the exercise of eminent domain, it is *not* police regulations and restrictions that have produced desirable effects upon private forestry abroad, but simply the example of a systematic and successful management of its own forests, and the opportunity offered by the Government to the private forest-owner of availing himself of the advice and guidance of well-qualified forestry officials.

That similar considerations should prevail and that similar organizations should be inaugurated by the individual States is evident, and some of the States, recognizing the value of their forest domain, have taken initial steps toward preserving it and preparing the way for better management.

How much forest property is held by the individual States or is under their control as school lands it has not been possible to ascertain for this report. It can be, however, only an inconsiderable portion of the total forest area, as the principles of our policy are opposed to the holding and managing of landed property by the State. As we learn to recognize not only the money value but also the general economic importance of forests, whatever forest soil reverts to the State or is still held by it will have to be managed on a different plan from that hitherto in use, by which it is often disposed of at inadequate prices and only a temporary benefit accrues to the community from the sale. The first step in this direction has been taken by the State of New York, as will appear further on.

PRIVATE FORESTS.

The bulk of the once endless forest areas is held by private persons and corporations, such as the railroad companies, to whom the land was granted by the General Government, by mine owners, by charcoal-iron works (holding about 3,500,000 acres*), tanneries, and other industrial establishments. The largest amount is in the hands of lumbermen, speculators, and farmers. This last class of forest owners must be considered the most desirable, since they probably form the most stable class of our population, and can devote the most care and attention to the management of their wood lots. It is a hopeful fact that nearly 39 per cent. of the reported forest area, comprising 190,255,744 acres, seems to have been in the census year in the hands of farmers. By the planting of trees and groves this area is receiving yearly additions in which the farming communities, especially those in the Western States, are almost exclusively concerned. It is to be hoped

*Report of Forestry Division on Charcoal Manufacturers' Interests.

that the farmers will pursue the most conservative policy in regard to this kind of property, which will shortly increase in value as never before, and will therefore offer great inducements to part with it prematurely.

DIFFICULTIES TO BE OVERCOME.

The difficulties in the way of a change of forest policy are the same which have produced the unsatisfactory state of affairs now existing over a large part of the United States. They are greater and of a different nature from those which European nations had to encounter, and therefore call for different methods of treatment.

In the first place, the peculiar and unique conditions under which the country has been settled have brought within reach of the market distant forest areas, where, in order to make lumbering profitable, in the absence of a near-by demand for inferior material and leavings, wasteful and destructive methods of utilization had to be employed. The phenomenally rapid development of our railway system, while it has aided more than any other enterprise in building up and settling this vast country, has also in many cases done irremediable damage to its future by inducing forest destruction.

Other conditions which have produced a tendency to wastefulness in regard to timber resources have been the necessity of clearing wood lands for agricultural purposes without a market for the timber; instability of ownership in real estate, together with a spirit of speculation, and therefore decreased interest in the future conditions and welfare of a particular locality, besides the prevailing ignorance of the importance of the forest interests and of forest management and the seeming inexhaustibility of existing natural supplies.

To this add that the enormous profits made by those to whom the Government sold her fair timber domain at nominal prices have incited such competition in the lumbering industry, that while the price of stumpage has been kept at profitable rates, the prices for lumber have been so reduced that many mills can be made profitable only when driven to their utmost capacity of production; and therefore little or nothing can be expected from the lumber industry in the way of voluntary restriction or in assuming additional expense for proper forest management.

The difficulty of protecting large forest areas in thinly settled regions against depredation and fire makes this class of property precarious to own, and holds out an inducement to dispose of it as quickly as possible.

The prices at present prevailing, due to the conditions just stated, do not represent the true cost of production of the raw material, and tend to make forestry for lumbering purposes appear unprofitable.

While small groves comprising timbers of certain kinds and sizes in the prairie States, and woods of spontaneous growth in New England or near large cities may yield profitable returns, we must not blind ourselves to the fact that, upon the basis of present prices for lumber, forestry for the production of building timber cannot be considered profitable in all localities. A considerable change in prices, however, may be confidently expected at an early period, and will no doubt place large forestry operations, begun at the present time, among the most remunerative enterprises for the future, provided that the objections arising from the present insecurity of such property are removed.

The necessity for husbanding supplies and for a proper division and

appropriation of forest and agricultural soil has not yet appeared pressing. There are still millions of acres of unoccupied agricultural land. But this is being settled at the rate of nearly 17,000,000 acres per year; and thus we may go on till the end of the present century before the readily available farm lands are disposed of. Then only will the necessity for a more careful use of our soils and agricultural resources become fully apparent, and the need and true value of scientific forestry make itself felt.

The ideas underlying our proprietary system are decidedly unfortunate with respect to the requirements of forestry as understood abroad and to some extent as conditioned in its very nature. The prevailing public sentiment which is opposed to the holding of land by Government, except for the purpose of national defense, &c., and the popular aversion to restrictive legislation in regard to the use of private property, conspire with other causes to interpose great obstacles to the adoption of any known forestry system, or, indeed, of any conceivable system possessing the characteristics essential to an efficient prosecution of the great public ends which forestry is designed to promote.

Forestry proper—that is, an industry contemplating a continuous production of wood to furnish material for the lumber supply of a nation, an industry which, like any other well-conducted business, aims to reap only the yearly or periodical interest, *i. e.*, in this case the yearly accretion on the forest area—involves—

(1) Large contiguous areas stocked with forest growth.

(2) A capital, represented by such area, tied up for a considerable time before paying accumulated interest.

(3) A careful management, yielding full results only after a term of many years.

(4) Considerable risks in sparsely settled countries from fires, which are liable to destroy capital and interest alike.

(5) In conclusion, a business in which the inaugurators have less interest than their successors, and which, therefore, according to human nature, will be neglected longer than any other, unless Governments or other continuous corporations engage in it or foster it.

Whatever the laws of supply and demand may do to regulate production in other directions, forestry as an industry is an exception, which needs the fostering care of a far-seeing governmental policy whenever demand begins to equal the supply from natural sources; for the adjustment of these economic forces in the production of lumber requires too long a period of time to be left entirely to itself. Meanwhile we should not disregard the hopeful view of forestry presented in the following table, showing the percentage of forest area held by farmers. While in Europe the small farmer is rightly considered the least desirable forest owner, in America we can proudly show that the mainstay of our country is in the conservative class of farmers, and that in their hands forest property is at least safer than in those of large holders or even of corporations.

To the farmers, holding nearly 38 per cent. of the total area of forest and much of the waste land capable of reforestation, we must look, therefore, for forest preservation and improvement, and their interest in forestry matters it will most benefit us to study and to encourage.

In the following table an attempt has been made to arrange the States in groups representing as far as possible an average of similar agricultural, forestal, and climatic conditions. It is to be regretted

not only that our statistics for each State are of the roughest, but also that a separation of the same for localities of similar forest conditions or requirements is utterly impossible. Yet the following division will allow us to form in a general way an idea of the prospects of different localities similarly conditioned in regard to forest conservancy.

The farmers' interest in forest property.

	Total forest area.	Proportion of forest to total area.	Forest area held in farms.	Proportion of forest in farms to total forest area.	Proportion of forest in farms to total farm area.	Area of land in farms unimproved, but not in forest.	Proportion of unimproved not in forest to total farm area.
	Acres.	*Per ct.*	*Acres.*	*Per ct.*	*Per ct.*	*Acres.*	*Per ct.*
United States	489,910,000	26.5	185,794,219	37.9	34.3	61,055,049	11.4
Maine	12,000,000	62.7	2,682,296	22.4	40.9	385,374	5.88
New Hampshire	3,000,000	52.0	1,296,529	43.2	34.8	116,532	3.1
Massachusetts	1,000,000	19.6	1,004,099	100.0	29.4	226,669	6.7
Rhode Island	200,000	46.6	182,666	91.3	35.3	33,661	6.5
Connecticut	650,000	21.0	646,673	99.5	26.3	164,680	6.7
Vermont	1,900,000	32.5	1,503,467	79.1	31.2	92,660	1.9
New England States	18,750,000	47.0	7,315,730	39.0	34.4	1,019,576	4.7
New York	8,000,000	26.2	5,195,795	64.9	21.8	867,097	3.6
Pennsylvania	7,000,000	24.3	5,810,331	83.0	29.3	558,003	2.8
New Jersey	2,330,000	48.8	708,092	30.4	24.2	125,384	4.3
Delaware	300,000	23.9	279,099	93.0	25.5	64,188	5.8
Maryland and District of Columbia.	2,000,000	31.7	1,637,330	81.9	31.8	145,305	2.8
Middle Atlantic States	19,630,000	27.4	13,630,647	69.4	25.8	1,759,977	3.3
Virginia	13,000,000	50.6	9,126,601	70.2	46.0	2,199,071	11.1
North Carolina	18,000,000	57.9	13,868,086	77.0	62.0	2,014,281	9.0
South Carolina	9,000,000	46.6	7,255,121	80.6	53.9	2,070,442	15.3
Georgia	18,000,000	47.7	15,269,225	84.8	58.6	2,569,327	9.8
Southern Atlantic States	58,000,000	52.4	45,519,033	78.5	55.7	8,853,131	10.8
Atlantic coast	96,380,000	43.4	66,465,410	69.0	42.6	11,632,684	7.4
Florida	20,000,000	57.6	2,186,601	10.9	66.3	163,083	5.0
Alabama	17,500,000	53.1	10,430,727	59.6	55.3	2,048,901	10.8
Mississippi	13,000,000	44.0	9,144,323	70.3	57.6	1,494,202	9.4
Louisiana	13,000,000	44.6	4,557,332	35.1	55.2	976,202	11.8
Gulf States	63,500,000	50.2	26,318,983	41.4	56.8	4,682,338	10.1
Texas	40,000,000	23.2	15,851,365	39.9	43.6	7,790,540	21.5
Michigan	14,000,000	38.1	4,452,265	31.8	31.5	1,058,113	7.6
Wisconsin	17,000,000	48.8	4,768,046	28.0	31.0	1,422,544	9.3
Minnesota	30,000,000	59.3	2,030,726	6.8	15.1	4,125,600	30.8
Northern lumbering States	61,000,000	49.9	11,251,037	18.3	26.4	6,606,257	15.5
Ohio	4,500,000	17.3	4,436,641	98.6	24.0	535,282	2.2
Indiana	4,500,000	19.6	4,379,759	97.3	29.0	551,937	2.7
Illinois	3,500,000	9.8	3,575,445	100.0	15.5	622,916	2.0
Northern agricultural States	12,500,000	14.7	12,391,845	99.1	22.0	1,710,135	2.2
Lake States	75,500,000	35.5	23,642,882	32.2	23.6	8,316,392	6.97
West Virginia	9,000,000	57.0	6,180,350	68.7	60.6	221,102	2.2
Kentucky	12,800,000	50.0	10,106,072	78.2	47.0	657,485	3.06
Tennessee	16,000,000	60.2	11,232,876	70.2	54.3	937,483	4.5
Arkansas	20,000,000	58.9	7,861,409	39.3	65.2	604,535	5.0
Missouri	16,000,000	36.4	10,137,790	63.4	32.8	996,455	3.6
Central States	73,800,000	50.5	45,518,497	61.6	49.3	3,417,060	3.56

The farmers' interest in forest property—Continued.

	Total forest area.	Proportion of forest to total area.	Forest area held in farms.	Proportion of forest in farms to total forest area.	Proportion of forest in farms to total farm area.	Area of land in farms unimproved, but not in forest.	Proportion of unimproved not in forest to total farm area.
	Acres.	*Per ct.*	*Acres.*	*Per ct.*	*Per ct.*	*Acres.*	*Per ct.*
Iowa	2,300,000	12.7	2,755,290	100.0	11.0	2,130,869	8.6
Dakota	3,000,000	3.2	80,264	2.7	2.1	2,569,979	67.6
Nebraska	1,500,000	3.1	321,566	21.4	3.2	4,118,558	41.4
Kansas	3,500,000	6.7	991,187	28.3	4.6	9,686,715	45.2
Prairie States	10,300,000	4.4	4,148,307	41.0	6.9	18,506,121	32.97
Interior States	84,100,000	22.3	49,666,834	59.0	32.6	21,923,181	14.4
Montana	25,000,000	26.9	3,678	0.014	0.9	139,394	34.4
Wyoming	7,800,000	12.5	510	0.007	0.41	40,801	32.8
Colorado	10,630,000	16.0	44,117	0.44	3.7	505,087	43.3
New Mexico	8,000,000	10.2	219,224	2.74	34.7	174,515	27.65
Eastern Rocky Mountain region	51,430,000	17.1	267,529	0.52	11.6	859,797	36.9
Idaho	10,000,000	18.5	11,892	0.12	3.6	118,499	36.1
Nevada	2,000,000	2.8	18,697	0.93	3.5	167,742	31.6
Utah	4,000,000	7.6	2,305	0.06	0.3	237,114	36.2
Arizona	10,000,000	13.8	13,399	0.13	9.8	66,103	48.8
Western Rocky Mountain region	26,000,000	10.4	46,293	0.17	2.8	589,458	35.7
Rocky Mountain region	77,430,000	14.1	313,822	0.4	9.7	1,449,255	36.45
California	20,000,000	20.0	1,672,810	8.3	10.08	4,251,234	25.6
Oregon	20,000,000	33.0	1,424,417	7.12	33.08	591,650	14.04
Washington	20,000,000	44.3	437,696	2.19	21.05	487,379	34.6
Pacific coast	60,000,000	34.0	3,534,923	5.9	15.9	5,330,263	23.99

New England, with the exception of Maine and New Hampshire, has nearly its entire forest area in the hands of farmers, and Maine lumbermen having begun a more conservative working of their remaining forest, that State may be considered equally safe.

The Northern Atlantic States, with the exception of New Jersey, show a quite satisfactory percentage thus safely owned; the proportion of such ownership in New York is increased to 75 per cent. by State lands now under management, and charcoal-iron interests in New Jersey will increase the safe percentage there also.

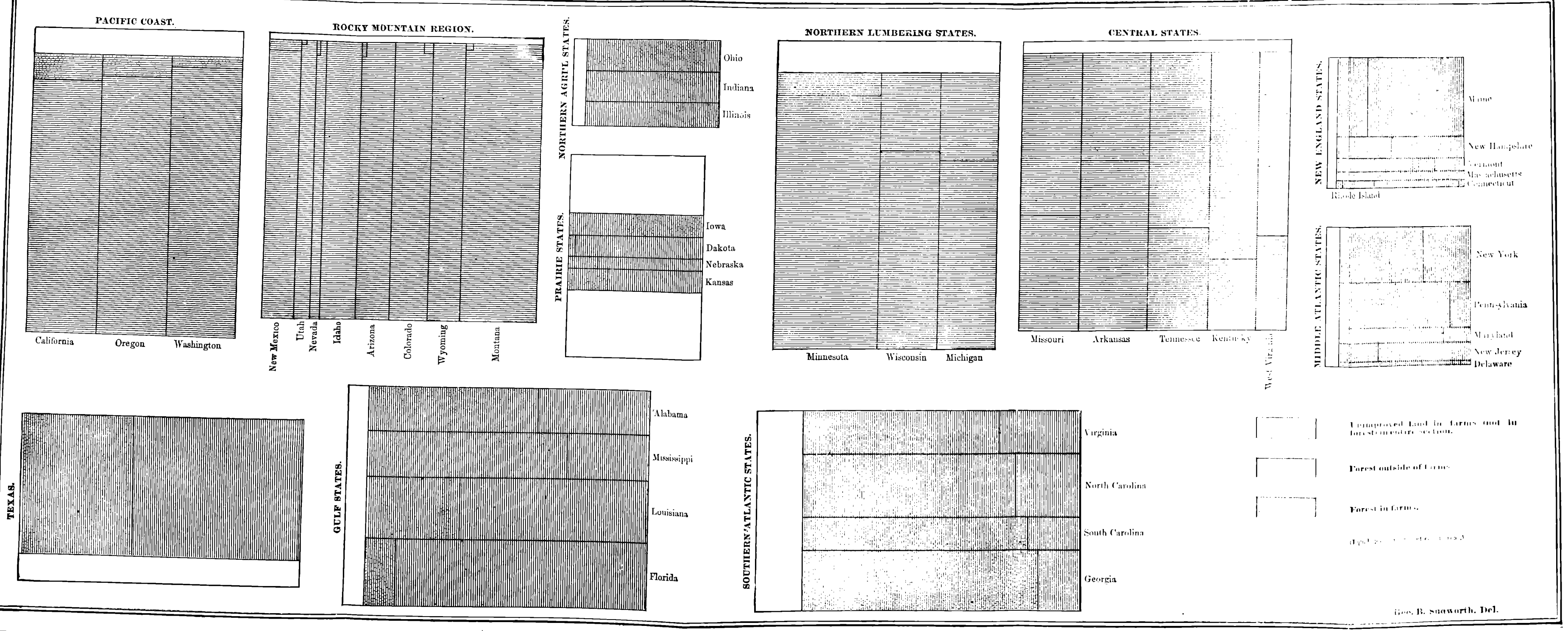
It is to be hoped that farmers in the Southern States, who have more than 50 per cent. of their farms in forest, will not part with this portion of their property to speculators as easily as developments of the last few years have led us to anticipate.

It is likely that the area of forest held by farmers is considerably less than it was in 1880, especially in the Gulf States, where Northern millmen have been buying up large tracts of pine and cypress lands.

The figures of the three States classed as Northern agricultural show some discrepancies, which may be explained by assuming that what was reported as forest in farms contained much that, as waste and useless brush, had been excluded from the total estimate.

In the prairie States much land is still unsettled, and all the forest

THE FARMERS' INTEREST IN FOREST PROPERTY



will ultimately belong to the farmer, greatly increased by the artificial plantations which are more and more spreading over the treeless plain.

The danger appears greatest in the mountain regions, and unless the State or National Government adopts a conservative policy little hope can exist for the forests situated there. They are mostly so far removed from agricultural lands as not to be easily included in farms, and while, as shown before, their existence is almost a question of life for the agriculture below, yet at present the agriculturist has little power for their control.

On the Pacific slope the danger is not less pressing. The possibility of getting small parcels of timber land (160 acres), under the timber and stone acts, having opened a more ready means of speculation in the timber of these important mountain forests, their destruction, regardless of consequences and new growth, is almost certain, unless checked by a changed Government policy.

The unimproved land in farms, but not in forests, can be said, at least in the eastern half of the continent, to represent soil of little value to agriculture but upon which forest growth is possible, and where farmers should begin their artificial forestry. In the prairie States this class of soil represents about 30 per cent., and while much of it might no doubt be used for agriculture, it may well be asserted that, if properly put into forest, this area would increase in prospective value, and improve the conditions of the neighboring fields far beyond the cost of such reforestation.

The accompanying chart represents at a glance the interest which the farmer has in the forest area still remaining, as well as the quantity of unused soil in each section which can be devoted to forestry as a profitable investment. Equal spaces denoting equal areas, the total quantities, as well as the proportion to other forest areas, are at once indicated to the eye.

FOREST PLANTING AND MANAGEMENT IN THE UNITED STATES.

So far as known in this office but very few extensive forest plantations exist. These are notably the often-cited plantation of the Fort Scott and Gulf Railroad and that of Mr. Hunnewell, near Farlington, Kans., of about one section (640 acres) each; a plantation of Mr. Burnett Landreth, of 300 or more acres, in Virginia; and those of the Messrs. Fay and others, along the sea-coast of New England. From Southern California also are reported plantations of considerable extent.

Small groves abound in the Western, especially the prairie States, and are found less frequently in the Eastern States, notably in Massachusetts. In the aggregate these plantations must amount to quite a considerable area, affording a hopeful prospect in respect to the creation of new forests. This hopeful prospect does not exist in regard to the remaining natural forests. With the exception of more carefully conducted lumber operations in Maine, where there is less recklessness than formerly in the destruction of young growth, and beyond the rarely enforced rules in regard to cutting on Government lands, recited in another place, no attempts at management, so far as known at this office, have been made; or if any have been made, they are so isolated and primitive as hardly to deserve mention or the name of management.

The fencing out of cattle from newly cut deciduous forest, or even from single stumps, to preserve the new growth—a precaution which

is taken by careful farmers in Pennsylvania and elsewhere—is the first step toward management; the farmers, again, are also the ones first to appreciate the value of thinning natural growth for the purpose of improving the remainder. But all such attempts still seem exceedingly isolated.

There should also be mentioned a few experimental plantations at several agricultural colleges, which, though not extensive, nor in most cases started with any special purpose or systematic plan, will be exceedingly valuable by and by as ready means for instruction in forestry when this shall form a part of their plan of studies; and even now, often by the very mistakes that have been made, they are rendered most instructive, affording means for the observation of tree growth and the interdependence existing between it and the many varying conditions in the artificial forest. The experimental railroad plantations have been discussed to some extent in my report on Western tree planting.

GOVERNMENT ACTION IN REGARD TO ITS OWN LANDS.

To protect its timber domain the General Government, through the Land Office, appoints "special timber agents," "with the duty of enforcing compliance with the several laws relative to protection and preservation of public timber and the rules and regulations prescribed thereunder by the Department of the Interior." "They should remember that it is not the purpose of the law to prohibit the use of so much of the public timber as may be actually needed by the *bona fide* settlers for agricultural and domestic purposes, but to prevent it from being made an article of speculation for the pecuniary gain of a few individuals to the detriment of the many, or from being wantonly wasted or destroyed."

Lawful taking of timber from the public domain includes:

*"Cutting on homestead and pre-emption entries before final proof for purposes of clearing and for buildings, fences, or other improvements, also cutting and selling any surplus of timber on lands to be cleared.

"On mineral lands, all citizens of the State in which the lands are situated are permitted to fell or purchase and reserve for building, agricultural, or other domestic purposes any timber, provided (1) that the same is not for export from the State or Territory where cut; (2) that no timber less than 8 inches in diameter, is cut or removed; (3) that it is not wantonly wasted or destroyed (the failure to utilize all of the tree that can be profitably used and to take reasonable precaution to prevent the spread of fires will be regarded as waste).

"The timber on military, naval, Indian, and other Government reservations can only be cut by persons employed by the Government for that purpose.

"All land-grant railroads are authorized to take timber from the public land adjacent thereto for construction purposes. (The Denver and Rio Grande Railroad is also authorized to take timber for repairs). The term "adjacent" is, or used to be by construction, extended somewhat indefinitely, as also the purposes for which the timber was taken.

"All right-of-way railroads are authorized to take timber from the public lands adjacent to the line thereof for construction purposes only. The persons cutting such timber must be in the actual employ of the railroad, and cannot cut and sell timber to the railroad at a piece-price.

"Trespassers are liable to both criminal prosecution and civil suit, as well as purchasers of timber unlawfully cut; but compromise is admissible in both or either actions if the evidence indicates that the trespass was not willful but unintentional, or if there are other extenuating circumstances.

"In the Pacific States and Territories the sale of timber land (unfit for agriculture), in parcels of not more than 160 acres, for the express purpose of benefiting the

*From various reports of the Commissioners of the General Land Office.

purchaser and for his own use and not for speculation, is permitted by the act of June 3, 1875.

"Instructions to the special timber agents require of them to 'use all possible means to check the progress and extinguish forest fires in their respective districts,' and 'to employ assistance and, if necessary, expend a reasonable sum for such purpose.'"

For the purpose of preventing or bringing to notice such trespasses as are possible under the foregoing privileges and otherwise, and of preparing the evidence for legal prosecutions, attending courts as witnesses, &c., during the last year, a service in the aggregate equivalent to that of twenty-one agents for twelve months, was employed,* over areas amounting in the aggregate to more than 70,000,000 acres.

Twelve hundred and nineteen cases of depredations or timber trespasses have been reported, involving a value of $9,339,679 recoverable to the United States; the amount recovered by settlement, sale of lumber, and through legal proceedings, as actually on record, amounted to $101,085.44, with perhaps an equal amount recovered but not yet reported.

As the agents are not clothed with police powers, but simply act as informers and legal attorneys, they moreover lack the desirable co-operation of the resident population, which makes the arduous duties of agents still more onerous and renders their services less efficient than they otherwise might be.

Of the individual States but few hold or control any lands, unless it be school lands granted by the General Government. Some of the States have taken decided action for the purpose of protecting their remaining forest property.

FOREST COMMISSIONS.

The State of New York, holding 715,267 acres of forest land in the Adirondacks, instituted in 1885 a Forest Commission with extensive power, and appropriated $32,500 for the work of the same. The first report of the Commission would indicate that this work has been begun with good intent and encouraging results, at least so far as securing the property against depredation by theft and fire; and the Commission is "receiving a hearty and intelligent support from the lumbermen and land owners of the Adirondacks and the Catskills."

It being recognized that protection against fire is the first consideration in any attempt at forest management, the Commission has vigorously undertaken to secure this protection.

The State of California has recently created a Forest Commission, with a moderate appropriation ($15,000), its attention being primarily directed to preventing forest fires, bringing depredators to justice, aiding forest planters with seed and other material, and making a forest map of the State.†

Of the Forestry Bureau of the State of Ohio it cannot be said that it was created with any definite policy in view, it having been appointed and provided with a small appropriation for the purpose of gathering information in regard to the forest condition of Ohio and making recommendations for legislation calculated to develop a rational system of forestry.

From the report lately issued it appears that in the thirty years from 1853 to 1884 the forest area of the State was reduced from 54.19 to 17.39 per cent. of the total area; a decrease which cannot have been

*Annual Report of the Commissioner of the Land Office for 1886.

†The first report, containing a very valuable account of the Redwood forests, has just appeared.

without serious influence upon the climate and water supply of the State and its river systems. The horrors of the last flood, still in our memory, may with good reason be connected with the rapid denudation of the tributary hillsides.*

The State of Colorado, too, ordered the appointment of a forest commissioner, but omitted to make any appropriation for him. Therefore the authority conferred upon him, giving him "the care of the wood lands of the State, and requiring him to make and publish reasonable rules and regulations for the prevention and extinguishment of fires thereon and for the conservation of forest growth," &c., could not be of much avail. In this emergency this Department enabled the commissioner appointed by the governor of Colorado to devote his time and energy, at least to some extent, to the interests of forestry, by employing him to report upon the forest conditions of the Rocky Mountain region. His valuable report is just completed.†

FORESTRY DIVISION.

The attention of Congress having been called repeatedly to the necessity for a definite forest policy for the United States, the Commissioner of Agriculture was required by an act of August 15, 1876, to appoint—

> "some man of approved attainments, and practically well acquainted with the methods of statistical inquiry, with a view of ascertaining the annual amount of consumption, importation, and exportation of timber and other forest products; the probable supply for future wants; the means best adapted to the preservation and renewal of forests; the influence of forest upon climate; the measures that have been successfully applied in various countries for the preservation and restoration or planting of forests; and to report upon the same to the Commissioner of Agriculture, to be by him transmitted in a special report to Congress."

After two reports had been prepared upon the subject by the late Dr. F. B. Hough, the work became in 1881 the object of a Forestry Division, as part of the organization of the Department, for the purpose of "investigating and reporting upon the subject of forestry." In 1884, without increasing the appropriation, the duty of making experiments was added to the functions of the Division; and in 1885 "the collection and distribution of valuable economic tree seeds" was also required, to which "plants" has been added for the present year.‡ No record of experiments is at hand, and the distribution of seeds has been very limited. On account of our large extent of country and its differences of requirement as to kinds of trees, this provision must

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*The value of the property in the Ohio Valley destroyed by the flood of 1883 has been estimated at $60,000,000. Nor will this seem an unwarranted estimate, large as it is, when we consider that the area drained by the Ohio River is not less than 214,000 square miles, or twenty-two times as large as that drained by the Connecticut. The Ohio Valley drains portions of thirteen States.

†The reappointment of Col. E. T. Ensign as forest commissioner, with enlarged powers and suitable appropriation of means, places the forestry interests of Colorado on a safer basis.

‡It is worthy of note that this mode of encouraging forest growing is quite extensively practiced on the Continent and elsewhere.

During the last year the Bohemian Forest Department and forestry associations distributed 4,600,000 seedlings, of which nearly 4,000,000 were coniferous. Double the amount is prepared for distribution next year. The same is done in Styria. The Hungarian Department of Commerce distributes plant material free on board cars. In 1884 the Prussian Forest Department distributed over 25,000,000 seedlings. The large subventions in material and in money granted by the French Government for reforestation have been often pointed out in former reports.

remain practically nugatory so long as only inadequate means are at its disposal. The result of the work of the Division as such has been published in two special reports, in addition to the two previous made by Dr. Hough, and in the annual reports of the Departmnet of Agriculture. In addition to this collected information, many letters of inquiry asking for instruction in regard to forestry matters find replies through the medium of the Division.

STATISTICAL INQUIRIES.

It has become a recognized fact that incomplete, and, therefore, unreliable statistics are harmful rather than helpful. While good results in statistical work can be expected only from a large and well-organized force of correspondents, conversant with and interested in the subjects of inquiry, and with some certain benefit to themselves resulting from their labor, the Forestry Division has not the means to employ such a force. It may be added that in this country forestry statistics are most difficult to obtain, both on account of the large area of sparsely-settled land and the lack of competent observers. Even in such a country as Germany, so densely settled and well administered as regards forests, a recent writer on the question of forest statistical inquiries finds it necessary to say:

> "The Government lacks greatly a sure basis for the realization of the purposes of its forests. When deforestation may be admissible, where required, where it has done damage, where reforestation is required and to what extent for the security of agricultural conditions, are all questions for the answer of which the data are lacking."

Most of the statistical work, then, of the Forestry Division, and the same will be true of other forest statistics, represents only an uncertain approximation to the actual condition of affairs.

A thorough statistical research in certain definite directions is a most urgent necessity. First of all, it would seem desirable to locate the timber domain still in the possession of the Government, and to determine its value as a source of lumber, or its economical importance, in order to furnish a basis for establishing a desirable policy in regard to its disposal or maintenance. The condition and present extent of the white-pine forests of the North should be ascertained as accurately as possible. The need of such investigation into this, the most important branch of our lumber industry, is apparent from the many expressions of lumbermen in their special papers.

An attempt to ascertain approximately the extent and conditions of the forest cover of the Northwestern States has been instituted by this Division by enlisting the school organizations of the States in the work. By this means it was thought that while securing an intelligent force of correspondents, the interest of the teacher in the cause of forestry might at the same time be engaged. The invitation to such co-operation has been cheerfully accepted in most cases by the school authorities. Whether by this means acceptable statistical results will be obtained remains to be seen. One of the agents of the Division, Mr. James Byars, of Covington, Tenn., is engaged in an exhaustive statistical research into the forest conditions and lumber resources of his own State.

A report on the dependence of railroad construction upon forest supplies by Mr. M. G. Kern, of Saint Louis, agent of the Division, has just been completed, giving in a number of Appendices important practical information to railroad managers regarding possible econo-

mies in the use of timber. Among these will be found the original investigations into the structure and use of certain railroad ties by Mr. P. H. Dudley, C. E., of New York; experiments in regard to the adhesion of spikes and the economy of different methods of fastening; a review and practical elucidation of different methods for the preservation of timber, by Col. H. Flad, C. E., of Saint Louis, and Mr. H. Constable, C. E., of New York, and an exhaustive report on metal ties.

A report on the relation of charcoal iron works to forestry has been prepared by Mr. J. Birkinbine, secretary of the Charcoal Iron-Workers' Association. Reports on the use of timber in mining enterprises and on the state of wood manufactures are in preparation.

It was thought that by such reports those interested in these industries might be aroused to the necessity of securing a continuance of supplies, and as many of the industries are carried on by owners of forest lands, their action leading to an economical and systematic management of these might be secured.

PHENOLOGICAL OBSERVATIONS.

The desirability of interesting our educational institutions in the work of forestry reform, which has been so strongly emphasized by some forestry advocates, has not been ignored. To bring the agricultural colleges and their students into active sympathy with the work of the Division, schedules for observations of plant development, relating notably to the date of the flowering, leafing, and fruiting of trees, were sent to the professors of botany for distribution among advanced students. To enlarge the class of observers, the members of the Agassiz Association, at their request, as well as private applicants, were supplied with schedules, so that quite a large corps of observers were engaged upon this work. By thus inviting students to personal and methodical observation of tree-life, under the direction of and in connection with the Forestry Division, it was hoped that such an interest might be incited as is thought to be essential to our future forest policy.

The principal aim of such observations, to be carried on through a series of years under certain prescribed conditions, is to arrive at some practical points of climatic comparison, or, as stated on the schedule:

(1) To note the progress of local development in tree life, for the purpose of enlarging the knowledge of biological conditions.

(2) To arrive at conclusions as to relative climatic conditions expressed by phases of plant development, and also, *vice versa*, as to dependence of such developments on such conditions.

(3) To determine the period of vegetation of different species (time from appearance of first leaf to general change of foliage).

(4) To ascertain the relative dependence of different species on climatic conditions, determining relatively the time for planting.

(5) To furnish comparison of the behavior of the same species under the climatic conditions of different localities, thus allowing preliminary estimates of the capacity of the species for acclimation..

It cannot be denied that the complex factors which we designate under the comprehensive term "climate" find most readily a satisfactory expression in the development of plants, and therefore, if by observations continued for many years on the same individual plants in different parts of the country we can establish the average occurrence of a certain plant phase, for instance the flowering, we shall gain pretty safe points for comparison between the climatic conditions

of different localities. Such observations were carried on through a series of years by the Smithsonian Institution thirty years ago, though not on a systematic plan. Yet by comparison with these data we shall get additional opportunity to judge regarding the change of climate, if any has taken place, since that time, and thus contribute to the settlement of the mooted question of forest climatic influences.

Even from one season's observations, made simultaneously in several places, deductions of comparative climatic conditions may be made.

BIOLOGICAL STUDIES.

Though many helpful notes may be found in the writings of botanists and horticulturists, yet no special studies of the nature of our timber trees, their life history, or the influences and conditions upon which their growth and reproduction in the natural forest depend, have been made or published in collected form with a view to the particular requirements of forestry. All or most of the facts which would enable us to apply, or to modify in applying, the principles of forestry established by long experience on the Continent are lacking, and in order to be able to give advice as to methods of forest management the systematic study of the biology, the life history, of our timber trees must precede the formulation of specific rules.

This work the Forestry Division has begun this year, and a number of able observers and botanists, with a practical turn of mind, have been engaged to make and compile in ready form the studies and observations on the life and behavior of our native species upon which the forester may proceed intelligently in his management. These studies will naturally require years for their satisfactory completion, as observations must be made in a great variety of localities and through several seasons. "We must gather and compile the experiences of many, through many years, from many localities, under many circumstances, derive principles therefrom, form rules, and learn to modify these." Besides, the forest flora of the United States is very extensive, and the number of capable botanists who are willing to engage in such a task, for which only the scantiest remuneration is allowed, is small, and thus this preliminary work will be unduly prolonged unless better facilities are granted.

As the coniferous trees are to-day, and will be for some time to come, the most important factors of our present forest wealth, and as their reproduction and management, especially with the unfavorable conditions under which our forests are worked, are among the most difficult tasks of forestry, attention has been first directed to the study of the most important of these, namely, the White pine of the North, the Long-leafed pine and the Cypress of the South, the pitch pines of the Western mountain ranges, and the fast-disappearing Hemlock, so important for our leather industry, soon to replace more largely the waning supply of White pine. The monographs on the White pine, by Prof. S. V. Spalding, Ann Arbor, Mich.; on the Long-leafed pine, by Dr. Charles Mohr, Mobile, Ala.; and on the Bald Cypress, by Prof. A. H. Curtiss, Jacksonville, Fla., have been completed. It is proposed to take up gradually the other important conifers and deciduous trees. In order to establish this work upon a uniform basis it was found necessary to formulate the subjects, and the following arrangement was prepared in this office to serve as far as possible as a schedule for studying the biology of our timber trees:

SCHEDULE FOR STUDYING THE BIOLOGY OF TIMBER TREES.

(a) *Introduction.*

Significance of the tree in the forestry of the country; short statement justifying the investigation; historical remarks; sources of information and acknowledgments of aid; statement of methods of inquiry.

(b) *Statistical.*

1. Geographical distribution and habitat; (in general by regions, where best developed, most abundant, covering large or small areas, continuously or only mixed in, associated with what other species, &c.).
2. Economical importance, utilization, trade, former and present supply, acreage, amounts used, available, &c.
3. Value and uses of the wood.

(c) *Biological.*

1. Short botanical exposé; name, size, form, root, crown, habit.
2. Life history; development from seedling; leaves, flowers, seeds, seed crops.
3. Influences, on form and development, of climate, soil, site, surroundings, and light and shade as compared with other species.
4. Measurements: rate of growth in height and in diameter, in natural forest or under cultivation; at different periods of life; on different sites; time necessary to produce merchantable timber; yield of wood per acre.
5. Structure of the wood and mode of its development; influences upon quality; illustrations.
6. Dangers and diseases:
   (a) From mechanical forces, human agencies, cattle, wounds, winds, snow, frost, drought, floods.
   (b) Occasioned by influences of the soil.
   (c) Occasioned by phanerogamic parasites.
   (d) Occasioned by cryptogamic parasites.
   (e) Occasioned by insects.

(d) *Forestal.*

1. Essential demands on climate, soil, and growing conditions.
2. Associates found naturally with the species and their relative behavior.
3. Opportunities and requirements for natural renewal (especially considering seed crops, seed years, germination, and the need of light or shade for young plant); difficulties for practical and economic reasons; for natural reasons.
4. Methods of management suggested.
5. Artificial renewal.
6. After treatment: Thinning; when and how much.
7. Rotations.
8. Profits under different treatment.

(e) *Conclusions.*

Stating in the briefest manner, in a few precise sentences, results of investigation in regard to economic and forestal questions.

INSPECTION OF WESTERN TREE PLANTING.

Under your direction, I made in September a very brief and hurried journey through Kansas, Nebraska, and Colorado, to inspect tree planting and its conditions in the once treeless regions. My observations have been embodied in a special report, from which to some extent may be gleaned the needs, the causes of failure, and remedies for the same, with hopeful views as to the possibilities of further extension of the tree planter's work into the arid regions. That the utilization of the military reservations for forest planting by the Government would be a most desirable encouragement for Western tree planters, and at the same time would enhance the value of agricultural lands near such extensive forest belts, has been pointed out and finds ready indorsement among those most conversant with the condition of those localities.

The need of aid by a systematic and rational distribution of suitable plant material, either gratuitously or at nominal rates—a work which could most readily be done from such experimental forests—

has been generally acknowledged by persons who are not themselves applicants for such aid.

At your request, I also attended the meeting of the American Forestry Congress in Denver during the month of September, when the presence of representatives from the States and Territories afforded an excellent opportunity for ascertaining from those best fitted to judge the prevalent feeling and opinions in regard to forestry. Though many diverging views as to the most desirable manner of procedure were advanced, the necessity of a change of policy at least as regards the use of the forest domain of the Government was unanimously declared to be urgent.

During the course of the year, as your representative, I have also delivered several addresses on forestal subjects before Forestry and other Associations.

LEGISLATION.

Legislation in regard to forestry may be considered under the classification of restrictive, protective, and stimulative legislation. Laws of the first and second class have been passed from an early period, and have been designed to prevent the indiscriminate cutting of timber, especially of live-oak, and to prohibit the unauthorized cutting or the injury of timber whether growing upon private lands or upon those belonging to the Government. The efficiency of these laws, however, depends, even more than that of other legislative acts, upon the greater or less ease with which the laws can be enforced. At present no laws restrictive of the use of forest property by the owner exist in any of the States.

Protective laws, directed against theft or the destruction of timber by man or cattle, and against incendiarism, are found in every State and Territory. These laws, however, have not exerted much protective influence. The law of a single State may be taken as a specimen of the whole, for there is a general similarity among them:

> "Any one willfully or negligently setting fire to any woods, prairies, or other grounds not belonging to him, or willfully or negligently permitting fire, kindled on his own land by him or by his permission, to spread to the injury of other persons, is liable to a fine not exceeding one thousand dollars or imprisonment not over one year, or both, at the discretion of the court. The party injured may recover double damages for the injury sustained."

While such laws may have some salutary influence, the difficulty of establishing willfulness or negligence must ever prove a great obstacle to the enforcement of them. Other difficulties also tend to make such laws ineffective.

Particular attention must be called to the salutary effect of stock or herd laws, existing in a few States (chiefly Western), by which not only young growth is protected against the incursions of cattle, but also the firing of the woods, which is practiced mostly to produce fresh herbage for the cattle, is restricted, and incidentally a large saving in the construction of fences is effected.

But even were the firing of woods made a criminal offense, as it certainly should be in view of the evil consequences it entails upon the country at large, it would be almost impossible to render the laws effective over the vast areas of timber land in private hands and in thinly settled regions, unless the spirit of the people were bent upon enforcing them.

Where private interests require protection private co-operation will

be the most effective protector, and where, as in the case of forest property, the State has an economic interest in its preservation beyond the mere protection of private rights, co-operation of the State authorities with the private interests is necessary. The adoption of what may be called the Canada plan is therefore recommended for such States as have large lumbering interests to protect.

The substance of this plan is given in the following paragraph. taken from the recent report of the Commissioner of Crown Lands:

"It is proposed that during the dangerous period, say from the 1st day of May to the 1st day of October in each year, there shall be placed on such limits as are exposed to danger a man or men who will be empowered and instructed to use every endeavor to prevent and suppress fires in every way possible, and the ranger who is placed in charge of a limit will be authorized to engage whatever help may be necessary to cope with a dangerous fire when prompt action is necessary. These men will be supplied with copies of the "Fire act" and instructed to post them up in public and conspicuous places, to visit each person resident on the limit and give them, if thought advisable, a copy of the act, explaining to them its provisions, penalty for its infraction, &c., and to endeavor to enlist their assistance and sympathy to make the act effective.

"The Department will leave the limit-holder to suggest the number of men who shall be placed on his limit, and, as it is of all things necessary that practical bushmen of good judgment and well acquainted with the limit should be selected, he, the limit-holder, will nominate the man to be placed in charge of the limit and his subordinates, if any, the Department reserving the right to limit the number of men to be employed on any limit and also to reject or remove any man whom it finds unfitted to discharge the duties of the position."

As to the expense incident to the working of the plan, the Government proposed to assume one half, the other half to be borne by the limit-holders.

So far as timber-limit holders agreed to bear their share of the expenses connected with the experiment a trial was made in 1885. Thirty-seven men were placed in the field and kept on duty from June to October. The effect of their presence was excellent. Fires were suppressed which otherwise might have become vast conflagrations, causing incalculable losses. Persons wantonly violating the provisions of the fire act were promptly brought to justice and fined, and a general and strong interest in the direction of preventing the start and spread of bush fires was created and kept alive.

At the close of the season the timber owners expressed their great satisfaction with the experiment and urged its continuance and extension.

Passing over the early measures for the encouragement of tree planting of the New York and Massachusetts societies for the promotion of agriculture, which date back to the beginning of this and the end of the last century, we find bounties of from $2 to $10 per acre for planted forest provided since 1868 by the State legislatures of Massachusetts, Kansas, (repealed), Wisconsin, Missouri, Minnesota, Illinois, and Nevada. Exemption from taxation to an amount reaching from $100 to $200 for every acre planted to forest is granted in Iowa, Nebraska, Maine, Connecticut, Dakota, Rhode Island, Washington, and Wyoming.

TIMBER-CULTURE ACT.

To encourage forest planting on the treeless prairies, the General Government made tree planting, under certain regulations, the consideration for the acquisition of public lands. One quarter-section, or an equivalent fraction, was to be planted and kept in growing condition for eight or more years, and to show 675 living trees per acre at

the time of proving up, in order to give title to the whole. According to the report of the General Land Office, the lands taken under this act at present comprise 30,998,855.52 acres, of which 652,001.49 have been finally entered for proof or have passed into the hands of settlers. According to the law, four years were allowed for the final planting of the quarter-section. There should, therefore, be found planted to forest at least one-quarter of the entries made up to 1882, or 4,414,289 acres. But as the time for holding lands entered under this act, as against other comers, "may run for thirteen years," and commutation to other classes of entry or relinquishment (for valuable consideration) is not prevented, this result is far from having been accomplished. The proportion of entries made under this act without securing the intended result of its provisions has been estimated by the Commissioner of the General Land Office at 90 per cent. The organic faults of the act have been indicated from the standpoint of a forester, in the report on Western tree planting.

ARBOR DAY.

Among the encouragements of forestry the establishment of what is known as Arbor Day deserves to be mentioned.

The credit of the inauguration of a day specially devoted to tree planting, from which it takes its name, belongs to Nebraska, in which State, by a resolution of the State Board of Agriculture, in January, 1874, the second Wednesday of April in each year was dedicated to the work of planting trees. The resolution was welcomed by the people of the State, and as a result it has been claimed that on the first Arbor Day, and during the year 1874, more than 12,000,000 trees were planted, and that there are now 100,000 acres of planted forest in the State.

The example of Nebraska was quickly followed, especially by those States most lacking forest growth. In Iowa, Arbor Day was adopted in 1874 by the State Horticultural Society. Since then it has been established by legislative enactment. In Michigan the governor proclaimed Arbor Day in 1876; and in 1881 it was formally established by the legislature. In Minnesota it was proclaimed by the State Forestry Association in 1876, and 1,500,000 trees were reported as planted that year. The day is now established by law. In Ohio, Arbor Day was established in 1882 by the legislature. In West Virginia it was extensively adopted in 1883, under the lead of Hon. B. L. Butcher, superintendent of public schools. In accordance with an act of the legislature, it was proclaimed in New Jersey in 1885. It was adopted the same year in Massachusetts and New Hampshire by the action of the State Granges of the Patrons of Husbandry, and has been adopted more recently by the legislatures of these States. In 1886 it was adopted by New York, Maine, Connecticut, Rhode Island, Pennsylvania, and Florida. It has been adopted also in Vermont, Georgia, Wisconsin, Colorado, and Indiana.

Recently the scope of Arbor Day has been widened and its interest increased by engaging the pupils of the public schools in its observance. The way has thus been opened for getting the facts relating to tree-growth and the practical uses of trees before the minds of old and young alike, and for creating and diffusing through the community a sentiment which promises much good to the cause of forestry. It is this educational aspect which makes Arbor Day a specially desirable means of forestry reform.

FORESTRY ASSOCIATIONS.

The first Forestry Association formed in this country seems to have been that of Minnesota (1873), which, with State aid previously granted, did much, especially by the publication of its *Forest-Tree Planter's Manual,* to encourage tree planting not only in Minnesota but also in other States. In 1875 a National Forestry Association was formed under the auspices of that well-known forest enthusiast, the late Dr. Warder, which, however, did not become active. The American Forestry Congress, in which the Forestry Association was also merged, was formed in 1882, and since then has met yearly, in different and widely-sundered localities, for the purpose of arousing public interest in the subject and promoting the formation of local forestry associations, as well as to forward any measures of desirable legislation looking to the protection and preservation of forests, and, by publishing from time to time its proceedings, to diffuse information on the subject. The disinterestedness of its comparatively few members in urging forestry reforms cannot be too highly extolled.

Following in its wake, and to some extent as an outgrowth of the work of this Association, local or State Associations have been formed in Ohio, Colorado, New York, and Pennsylvania, the Gulf States being represented by the Southern Forestry Congress, with the same object of forwarding, by discussion and publication, the interest of forestry in their particular localities.

In other States, where such associations have not yet been formed, the horticultural or agricultural societies have devoted much attention to the subject of forestry, and by their discussions and publications have done much to advance its interests. Among those deserving special mention are the Massachusetts Horticultural Society and the Societies of Michigan, Iowa, and Kansas.

The most recent action of associated interests in forestry is reported from the State Grange of Maine, embracing a membership of 15,000 farmers, which, by the appointment of a committee on "arbor day and forestry," has committed itself to the subject.

As the farmers hold nearly 38 per cent. of our forest area, this move must be considered highly important, and it is to be hoped that the granges all over the country will follow and bring their best efforts to bear upon the needed reforms in the use of our forest resources.

INSTRUCTION IN FORESTRY.

There are no schools of forestry in this country,* nor are there regularly appointed chairs of forestry in any of the colleges or universities. In some of the agricultural colleges the professor of botany has the title "and forestry" added, but instruction, if given at all, is only incidental. Occasional lectures on forestry subjects have been given at the University of Pennsylvania from time to time, in accordance with the provisions of the "Michaux fund." A conception that forestry is a distinct branch of economics and not identical with arboriculture, or simple tree planting, has not yet found entrance into our institutions of education.

*The recent report of the California forest commission mentions that a forestry school is being inaugurated at Los Angeles in connection with the University of Southern California.

LITERATURE.

There having been no attempt at artificial or scientific forestry until very recently by the tree planting of the West and in a few instances elsewhere, the literature of the subject in this country is naturally very limited. The largest part, to be found in magazine articles, essays, the proceedings of associations, and other papers, is of a general nature, dwelling upon the importance, value, or history of forestry, or is a recital of European methods.

Forest floras and descriptive forest botanical works are met in sufficient numbers, some giving necessary instruction in regard to the propagation of trees; but an exposé of the principles which underlie forestry proper is, for the most part, not even presented by those who profess to write on forestry. It is to be regretted that the only periodical devoted to this subject, the *American Forestry Journal*, edited by the late Dr. F. B. Hough, had to be abandoned after one year's issue (1883) for lack of support. The English *Journal of Forestry* having also been abandoned, no forestry periodical in the English language is in existence except *The Indian Forester*, which deals specially with tropical conditions. A *Forestry Bulletin*, issued by the American Forestry Congress, had also to be abandoned for lack of interest. The Pennsylvania Forestry Association has recently issued several numbers of leaflets, *Forestry Leaves*. The Agricultural press, and the daily and weekly newspapers also, are beginning to introduce forestry matter liberally into their columns.

A pretty full collection of works on forestry, published in Great Britain, together with some continental publications, may be found in the Congressional Library at Washington and in the public libraries of Boston and New York, and a few elsewhere.

FOREST POLICY.

Recognizing the importance of the forests, on account of their direct and indirect bearing upon the development and continuous productiveness of a country, almost all civilized nations have devised systems of forestry, at least so far as government holdings of forest areas are concerned, and encourage and protect similar systems of management by private holders, in some cases even enforcing such systems upon them. Enforcement, however, is as yet practised only in very rare and urgent cases (contrary to the conceptions prevalent in this country), the necessity of forest police regulations having been recognized abroad only in recent times.

All Governments, however, are gradually awakening to the need of such forest policy, and, further, to the desirability of preserving certain forest areas in the hands of the Government, which alone can have a sufficient interest in the future conditions of the country dependent on forest cover. Thus, in Austria, where, since 1825, financial straits of the Government have necessitated the sale or mortgaging of more than 50 per cent. of the public domain, a new policy was inaugurated in 1868, by which were rigidly excluded from sale—

(1) All forests which, on account of climatic considerations—for the protection of water-sheds and for the conservation of favorable agricultural conditions of extensive regions or particular localities—ought to remain in the hands of the Government.

(2) Such forests as are needed for carrying on salt-works and similar Government establishments.

(3) Such forests as promise so insignificant a yield or profit at present as to make their preservation for future requirements desirable.

In Australia, the conditions of which, politically, economically, and often climatically, are somewhat similar to ours, systematic forestry has been introduced lately, and in such a manner and with such success as should invite imitation.

The report of the Woods and Forests Department (J. Ednie Brown, Conservator of Forests) for 1885–'86 shows that since 1876, *i. e.*, for ten years, the expenditures for this department were, in round numbers, $284,000; the revenue, $287,000; and in addition to the balance of revenue the approximate value of permanent improvements secured is estimated at $729,000.

Among the expenditures appears, for raising of trees for free distribution during the last four years, $8,000. The trees reported alive cost the government 1½ cents each. The area reserved by the government, at first comprising 239,368 acres, has been increased to 257,324 acres, of which, however, 92,000 acres are not intended for permanent forestry. Six thousand six hundred and eighty-five acres have been inclosed and planted, mostly in the arid regions and under trying circumstances.

The revenue is derived chiefly from leasing lands for grazing or agricultural purposes and from timber licenses. The success of this modest experiment undoubtedly lies in allowing one competent man to remain in charge of the work from its inception, and granting him liberty to administer the property according to his best judgment. The effect of the good example of the government upon the public is commended in every annual report, and in that of the present year in the following words:

> The results which will accrue to the colony at large will be boundless in their utility and embellishment. In a treeless country such as ours the planting of trees becomes a national necessity, and not merely an individual hobby, to be taken up or abandoned as caprice may direct. The Government cannot *compel* a man to plant, but it may persuade him to do so.

NOTE.—To enable us to form an idea of what forestry means in the household of a nation the following figures are given, based upon the results of ten years of government forest management (1870–'79) in the fourteen prominent states of Germany, assuming that the same conditions prevail in private forests:

The Government forests embrace 12,000,000 acres, or 35 per cent., and the private and communal forests 22,000,000, or 65 per cent. The total forest area is 34,000,000 acres, or 25½ per cent. of the total area of Germany.

Amount of wood produced yearly, 1,870,000,000 cubic feet (55 cubic feet per acre), which may be considered the yearly accretion, of which timber wood (above 3 inches diameter) forms 27 per cent., or 6,000,000,000 feet, B. M. Total gross income, mostly for wood, amounts to about $95,000,000, the total expenditure being about $38,000,000; making a net yield of $57,000,000. Of the expenditures, 16 per cent. goes for cultivation, improvements, roads; 32 per cent. for lumbering; 42 per cent. for administration or protection. The bulk of this expenditure is almost entirely for salaries and wages, in which the laborer receives 15 per cent. more than the officials. The price per cubic foot of wood averages about 5 cents, costing 0.7 cents to cut. The expenditures, amounting to $1.12 per acre, or 2 cents per cubic foot, represent 40 per cent. of the total gross income. The net income from each acre of wood land amounts to $1.60. This, then, represents the interest on the capital invested in the forest area, and, reckoning 3 per cent. as rate of interest, and the rotation at which the forest is worked in the average at ninety years, (these figures corresponding to German practice), the capital value of the German forests equals nearly $2,000,000,000, and the wood capital, of which only the yearly accretion is used, 80,000,000,000 cubic feet, or, reckoning the price of wood on the stump at only 2 cents per cubic foot, represents $1,600,000,000, and the soil not quite $400,000,000, showing the forest growth to have four times the value of the soil. It is to be added that most of this forest stands on a soil agriculturally useless.

To show the relation which different parts of a European state forest management hold to the whole system, the budget of the Prussian forest department for the

year 1886–'87, with an area of 6,617,712 acres (of which 673,816 acres are not devoted to wood growth), is given as follows:

Income according to average of last five years:		
1. For wood		$11,876,200
2. For by-products		991,000
3. Sundries		477,320
Total		13,344,520
Expenditures:		
1. Administration salaries, &c. (33.8 per cent.)	$2,487,380	
2. Labor and material (56.7 per cent.)	4,200,525	
3. Forest scientific purposes (0.6 per cent.)	44,840	
4. Miscellaneous (8.9 per cent.)	660,040	
		7,392,785
Net income		5,951,735

Of this $367,000 are expended in buying off privileges and $220,000 in buying additional forest ground. The cut of wood amounts to 272,388,390 cubic feet, or 41 cubic feet per acre, of which about 30 per cent. is inferior fire-wood.

Comparative areas of farm, forest, and other land in the United States and in Europe.

Countries.	Areas.	Agricultural soil in actual use (in U. S. 300,000,000 acres).	Forest (in U. S. 490,000,000 acres).	Waste or unoccupied, but capable of production (in U. S. 800,000,000 acres).	Roads, water, and land incapable of production.		Agricultural soil per capita.	Forest per capita.
	Acres.	*Per cent.*	*Per cent.*	*Per cent.*	*Acres.*	*Per cent.*	*Acres.*	*Acres.*
United States	1,750,000,000	17.10	28.00	45.70	160,000,000	9.14	6.00	9.8
Germany	133,421,492	60.76	25.62	9.70	5,235,519	3.92	1.09	0.79
Austria	153,820,044	54.70	31.30	8.00	9,229,311	6.00	2.35	1.33
Switzerland	10,252,099	32.00	18.80	20.00	2,993,490	29.20	1.19	0.69
Italy	63,546,066	65.00	20.00	7.78	4,589,821	7.22	1.48	0.47
France	130,616,662	63.35	17.70	13.50	7,108,713	5.45	2.25	0.62
Belgium	7,278,625	78.43	12.00	3.20	462,837	6.37	1.06	0.17
Netherlands	8,147,710	59.29	5.97	23.23	937,782	11.51	1.25	0.12
Great Britain	77,692,866	60.55	3.23	30.35	4,564,121	5.87	1.38	0.07
Denmark	9,441,825	67.97	4.61	17.27	958,539	10.15	3.35	0.22
Sweden	109,272,783	10.50	*39.50	40.87	9,971,135	9.13	2.59	9.75
Norway	78,258,007	2.70	*30.64	53.68	10,163,387	12.98	1.17	13.19
Russia	1,336,876,607	30.00	38.00	27.42	61,216,807	4.58	5.43	6.89
Turkey	130,336,347	20.00	24.00	37.91	23,569,351	18.09	1.73	2.07
Greece	12,385,894	16.00	11.80	27.50	5,536,252	44.70	1.36	1.01
Spain	125,461,700	44.30	16.30	25.00	18,066,459	14.40	2.32	1.23
Portugal	22,938,974	50.00	5.00	30.00	3,440,759	15.00	2.45	0.25
Europe	2,409,757,701	35.95	31.29	25.79	168,044,190	6.97	2.79	2.45

* The most recent returns reduce the percentage of forest in Sweden and Norway to 24 and 25 per cent. respectively.

The figures here given, so far as they relate to other countries, are taken from European statistical tables, based upon the state of things existing in 1880. No such exact figures can be given for our own country. In the estimates and approximations, given in round numbers, neither Alaska, the Indian Territory, or Indian reservations are included, the forest condition of these not having been ascertained. The forest area is taken from an estimate made by the Forestry Division in 1885. For the amount of farm land under cultivation, as well as for unoccupied and waste land, whether capable of profitable use or otherwise, reliance has been placed upon the census returns. The per capita estimates are made upon the basis of population in 1880, viz, 50,000,000.

FORESTRY.

It is to be regretted that the tendency of American writers on forestry has been to conceive of it mainly as involving tree planting and the idea of creating new forests by artificial means, while our millions of natural forests were permitted to be slaughtered with entire disregard to the dictates of forestry. The application of forest management to them has been entirely overlooked.

So little is the nature of forest growth understood, that lumbermen and prominent owners of white-pine mills have even asserted that the reproduction of white pine cannot be, or at least is not, effected by seed. Common sense and the experience of New England in its spontaneous white-pine growth should have prevented the utterance of such statements. Vast stretches of the finest white-pine forests have been needlessly laid waste, and the presumption is that the Southern pineries will be utilized with the same reckless devastation. The hardwood forests and coppices of the farmer, which could most easily have been kept in an ever improving condition, have been deteriorated unnecessarily for lack of knowledge of the first principles of forest management.

It has been often popularly stated that what we most want to know is: What to plant, how to plant, and where to plant. But before answering these questions we should first ask: For what object do we wish to plant? since the method of planting and of future management of the plantation, as well as the kind of timber to be selected, depend largely upon the answer to that question.

Forestry, like agriculture, attempts by correct management to produce, without exhausting the soil or favorable conditions of growth and at the smallest expense, the best possible returns. This may mean either the greatest amount of wood in a given time, as when working for fire-wood or charcoal billets, or the production of certain sizes in the shortest time, as when a farmer wishes to supply himself with posts and rails and short tool-stock, or else the production of the highest soil rent—financial success, for which the lumbermen will work.

Either of these objects will of course blend with the others; yet as one or the other object is prominent, it is but natural that the methods of management, as well as the choice of timber, &c., should vary.

On mountain-sides and on the prairie an additional consideration, the indirect influence of the forest on water regulation and climate—shelter forest—again modifies the method of management.

It would, therefore, be impossible to give general advice as to forest management applicable under all circumstances; yet, besides the more or less well understood methods in the propagation of *trees*, there are certain principles of *forestry* by which *forest planting* is distinguished from *tree planting*, and which have also a general bearing on all methods of forest management.

The arboriculturist, the nurseryman, the landscape gardener, and the roadside planter, has for his object the individual trees, or at best a group of trees, in their outward appearance. Into forestry several considerations enter, which the arboriculturist may neglect. The forester has to do with an aggregate of trees; he must study and take account of the relation and the influence of one on the other in their individual development through a long series of years, during which each species shows changing habits and differences of development. As he does not wish simply to grow trees, but to produce

a crop, he must consider and prepare conditions which will favor the best and quickest development of his crop for a given purpose. And, as his crop should be a paying one, he must consider the cheapest and surest methods of preserving favorable conditions for it. While, therefore, mulching may be a very good thing for tree growth, it will prove in most cases too expensive in forestry; and while plowing and cultivating may be the best method for the nursery, to keep out weeds and stimulate growth, for forest purposes other methods might be economically substituted. Again, while turfing under the lawn tree improves the object of the tree, viz, its beauty, it can only injure its object in the forest, which is wood production. In the limited scope of this report it will not be possible to do more than indicate the most important general principles.

GENERAL PRINCIPLES OF FORESTRY.

1. A careful and constant preservation of soil humidity and prevention of its undue exhaustion by surface evaporation.
2. Such choice and arrangement of species as will aid each other and not impede their best or the desired development.
3. For financial reasons, such methods of initial and later management as will reduce the expense of labor to a minimum.
4. For continuity of the least expensive forestry system such methods as will reproduce the forest naturally.

Regard to the first principle requires a constant and continuous protection of the soil against the drying influences of sun and wind. It is mainly for this that close planting has been, or is to be, recommended. The war against underbrush and the notion of a "clean grove," in which the trimming of "superfluous" branches and twigs occupies the loving care of the amateur planter, are two monstrosities, against which a serious protest should be made for the sake of successful forestry.

On the other hand, the weeds which spring up under the partial shade of the tree growth cannot be counted, as some writers have done, desirable undergrowth. They are not "nurses" but "curses" of forestry. In Russia, on the arid steppes, where the hot sun and dry winds favor rapid evaporation, the first step of the forester is the creation of an underbrush, often with a quick-growing willow (*Salix pruinosa*) which prepares favorable conditions for its betters.

Therefore, where land is to be devoted to forestry—and this should properly be such as cannot be utilized for agricultural purposes—the first object of the planter should be to cover the ground as quickly as possible with a dense wood-growth, which by its shade will create its own conditions of vigorous growth: increased and longer-available soil-humidity.

In their youth most tree plants have a more or less dense foliage, but with increased age a tendency to thin out is manifested in different degrees by different species. The condition of the soil, especially its depth, the nature of the subsoil, moisture and drainage, and also climate, modify the tendency in the different species. The walnut, generally a shady tree, on thin soil soon appears with a thin foliage. The birches, usually among the trees needing most light, will endure considerable shade on a fresh, humus soil.

A classification of trees according to this tendency is of importance for the forest planter, as he must keep his ground shaded through the long period of forest growing. The shady trees which preserve their

dense foliage are the only ones which should be planted in forests by themselves. Such are the beeches, catalpas, hornbeams, spruces, firs, and hemlocks, and on some soils perhaps the white and yellow pines. But the unmixed growth of larch can only result in ultimate failure, unless soil conditions are unusually favorable, as the requirement of the larch of a cool and moist soil is not aided by its thin foliage. The practice of planting, unmixed, the thin-foliaged Scotch pines in the northern plain of Germany is excusable only, but not commendable.

The planting of ash on thin soils, and of walnut or oak, without some dense-foliaged companion or underbrush, can result only in the deterioration of the soil and the consequent diminished wood production, as may be noticed in many groves on our prairies. Of the cottonwood plantations it is needless to assert that they present the deteriorating influences of a thin and constantly thinning foliage in an aggravated manner, and that, but for some considerations other than those of good forestry, their widespread use on the prairie, especially in unmixed plantations, can only be deplored. Their only recommendation is that they are easily produced, and fast growers; but they are short-lived, their wood inferior, and their effect on the soil disastrous.

Mixed planting, then, should, once for all, form the rule. The following reasons for mixing or grouping forest trees have been given, viz: The objectionable uniformity of unmixed growths, the advantage of a variety of material, differences in the food requirements of different species, and especially the difference of their root systems. But, though some of these considerations are weighty, more cogent reasons are, the greater ease with which the soil can be kept continually under cover and its humidity preserved, and the protection from injuries by wind, fire, fungi, and insects which is afforded in mixed growths. This preservation of favorable soil conditions can be accomplished in unmixed growths only by planting those species which preserve a dense foliage and enrich the soil by an abundant leaf-mold; but there are only a few such species.

Admissible in pure growths only are the thinly foliaged evergreens, like Scotch pine, under which a moss cover generally compensates for the missing shade. As soon as grass appears, however, the deterioration of the soil has begun, and requires the correcting interference of the forester. On deep and naturally moist soils of course the same means for the preservation of soil humidity may not be necessary, and less shady kinds, especially for short rotations, may be planted by themselves; for, as stated before, in their youth all trees have a rather dense foliage. The preference, however, must in all cases be given to a mixed growth. The advantages of mixed growths have been more fully described in my report on Western Tree Planting.

The mixture may be started simultaneously, or other species may be introduced later into the originally pure plantation; it may be with plants of the same age or of different age and size, as, for instance, by sowing under the planted rows. It may be a temporary or constant mixture, accordingly as we remove one kind earlier than the other or let all grow on.

The advantages of mixtures have now and then been pointed out before by writers on forestry in this country, as well as the reasons for close planting, but neither the true and most important rationale for such practice has been presented, nor, what is still more to be regretted for practical application, has the rationale of a correct mixt-

ure been given; the advice having mostly been simply to mix, the more the better. The variety of possible mixtures, with our rich forest flora, enlarged by a few desirable foreign trees, is almost endless, but, as outlined above, only a limited number will satisfy the requirements of good forestry. With these requirements in view, after we have determined what kinds are desirable and suitable to be planted in a given locality, the possibility of mixing two or more kinds depends—

(*a*) On their relative capacity for preserving or increasing favorable soil conditions;

(*b*) On their relative dependence for development on light or shade; and

(*c*) On their relative rate of height growth.

The densely foliaged and evergreen trees are best adapted to keep the soil in proper condition. The first named are also capable of sustaining a considerable amount of shade without being appreciably impeded in their development, while those with a thin foliage are easily shaded out, often even by the moderate cover of their own kind, though differences of soil, climate, &c., modify this susceptibility. It is their relative dependence on light, together with their relative rapidity of height growth, which are most important for the determination of the kinds most suitable for mixtures. It is this difference of requirement and development which accounts for the variety of vegetation in a natural, especially a deciduous, forest, and for the alternation of species so often observed in this country, when man, by clearing, has altered the conditions of growth. The light-seeded, quick-growing, light-needing aspens, maples, and birches are the quickest to occupy the ground, until the shade-enduring and slower-growing kinds have patiently struggled upwards, when they in their turn crowd out the first occupants.

The careful observations and measurements which are necessary for a more satisfactory discussion of specific mixtures, and to which mixtures our own forest flora is best adapted, have not been made, and even notes from which deductions are possible are scarce, because these relations of tree growth have seemingly never been pointed out or understood in this country.

We can at present, therefore, give only the general rules for mixing which may be deduced from the foregoing remarks.

Rule 1.—The dominant species, *i. e.*, the one that occupies the greater part of the ground, must be one that improves the soil conditions, generally a shady kind.

Rule 2.—Shade-enduring (*i. e.*, densely foliaged) kinds may be mixed together when the slower-growing kinds can be protected or guarded against the overshading of the more rapid grower, either by planting the slower grower first or in greater numbers or in larger specimens, or else by cutting back the quicker-growing ones.

Rule 3.—Shade-enduring kinds may be mixed with light-needing kinds when the latter are either quicker growing or are planted in advance of the former or in larger specimens.

Rule 4.—Thin-foliaged kinds should not be planted in mixtures by themselves, except on very favorable soils, as in river bottoms, marshy soil, &c., where no exhaustion of soil humidity need be feared, or else on very meager, dry soils, where most shady trees would refuse to grow and one must make a virtue of necessity.

Rule 5.—The mixing in of the light-foliaged trees in single individuals is preferable to placing them together in groups, unless special

soil conditions make the occupation of certain spots by one kind which may be better adapted to them, more desirable, as, for instance, the ash in a wet ground (slough). When a slower-growing, light-needing kind is to be grown side by side with a quicker-growing shady one—as, for instance, oak and catalpa—a group of oaks will have more chance to withstand the shade of the densely foliaged catalpa than the single individual.*

WHAT TO PLANT.

The first difficulty which besets the forester in this country is the question, Which, in the immense forest flora, are the trees that for artificial forestry are the most acceptable, the most promising? For, while nature in her lavish bounty has given us an almost endless variety of arborescent plants, and while we know how to put them to use when found, it is evident that, as natural resources are being exhausted and it becomes necessary to provide for our needs by artificial planting and by managing to produce on the smallest area the greatest amount of the best material, we shall have to be careful in the selection of the material as well as in the method of its management. For the settlement of this question we are remarkably destitute of reliable data, and while we may now plant some of the kinds which we know are adapted to special localities and are useful for certain purposes, yet for extensive planting it is well to confine ourselves to the few varieties which are best known until a closer study has been made of the capabilities of the rest. This is especially advisable with foreign species, or those not indigenous to the given locality. An exception might be made of European species only, as the extended experience in their cultivation abroad may serve as a guide here. We must, however, take care not to overlook the fact that, climatic conditions being different, differences of behavior are to be expected and, if possible, to be provided for. As an illustration of the mistakes which may be made in this respect, I may refer to the unqualified recommendations to plant the European larch anywhere and

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*Some of the above principles having been pointed out to Prof. W. J. Beal, of Lansing, Mich., he has made some notes on the relation of undergrowth to the development of different forest trees, and the capability of the latter for holding their leaves, *i. e.*, thriving under shade. These observations, published in a bulletin, have reference to conditions of a very limited locality, however, and may not, therefore, be generalized upon. He found under these conditions that black walnut, butternut, and white ash do not preserve dense crowns when grown in the forest. He further cites beech, sugar-maple, dogwood, hazel, blue beech and choke cherry, as shade enduring, and adds poplars, white oak, and swamp oak (these are generally light needing); white pine, arbor vitæ, red cedar, Norway spruce, of evergreens, and black cherry, American elm, butternut, low willows (unusual!), catalpas, birches (exceptional!), and box-elders. As the degree of shade under which these thrive is not indicated by a statement of the conditions under which they are found, besides relating only to the first period of life, this list is of little use. The oak, it is true, will live under shade, but for its development requires a great deal of light, and must, with few exceptions, be counted among the light-needing, thin-foliaged trees.

He also cites the weeds found to thrive in shade (what degree of?): common milkweeds, desmodium, celandine, wild asters, golden rods, to which add black cap raspberries, and grape-vines. June grass and some other grasses make their appearance late in autumn and early in spring, when deciduous trees are without leaves.

After cultivation ceases, shepherd's purse, annual poa, pigweeds, purslane, and other annuals appear. These weeds cannot exactly, as it is stated, be welcomed in the forest, but their appearance or disappearance furnishes the forester an indication of the condition of his plantation in regard to cover, and gives him warning that his correcting hand is needed.

everywhere and in pure growths, when it has been long a well-established fact that this larch, a mountain tree from the highest and coolest elevations (3,000 to 5,000 feet up to the limit of tree growth), when transplanted into the plain cannot be expected to be grown successfully to a mature age unless the conditions of its home are to some extent provided. To do this it will be necessary to assign to it the coolest exposures, to plant it only in single individuals through the forest, and to take particular care to shade its foot well with dense under-growth or densely foliaged companions, while its crown is kept in full enjoyment of the needed supply of light. If treated in this manner no more desirable and profitable exotic could be suggested. Its requirements for moisture being great, and at the same time its foliage being thin, it cannot, in spite of its rich leaf-mold, preserve the soil humidity under its deficient shade, and requires, therefore, the assistance of a neighbor better qualified to preserve favorable conditions. None better could be suggested than the densely foliaged, not quite as rapidly growing, Norway spruce, which will thrive well under the partial shade of the earlier-grown larch, and these in combined strength will prosper for many decades, making excellent lumber in a short time, enriching the soil for coming generations, and defying all objections to their foreign ancestry.

HINTS AS TO PLANTING.

Concise rules as to the manner of planting cannot be given here, this being too much dependent on local conditions. The following considerations, however, may well be kept in view everywhere:

1. Planting in most cases should have preference to sowing. Sowing is usually cheaper in its first cost and more quickly done over large areas, and furnishes fuller stands without increased expense. But planting is surer, because the young plants can be protected in the nursery against harmful influences which beset them in their first years; and thus, in the end, planting may even prove cheaper than sowing, especially when seeds are expensive.

2. For forestry purposes use seedlings (one to three years old); young plants suffer least from removal; they are, therefore, surer to succeed; they are also more cheaply handled. Older plants (from 2 to 10 feet high) may be used where trees have failed, or in "frost-holes," or for standards in the standard coppice, &c.

3. Transplanting can be done, with care, all the year round, but best in fall or spring. In favor of fall planting it is urged that the young plants regenerate their injured rootlets during the winter, and that the earth packs more closely around the roots; against it is the danger from winter cold and greater expense in the work on account of shorter days. Spring planting, especially on dry soils, should proceed early and be finished several weeks before leafing out, except in the case of most conifers which will transplant well even after budding (except the Larch). Heeling in plants in the fall facilitates planting in spring. The best time to plant is on rainy or cloudy days and in the afternoon.

4. Commonly a distance between the plants of 3 to 5 feet is recommended; the smallest distance for slow growers, which do not close their crowns and shade the soil soon; the widest for quick-growing, light-needing kinds.

5. Preparation of soil depends on soil conditions. A thorough cultivation on the prairies is desirable, but not decidedly necessary in the Eastern States. Place the plants as deep as they were in the nursery, if anything a little deeper on dry soils.

6. Be chary in trimming; only trim off smoothly any injured roots and the top to correspond.

Never expose roots of trees to the wind or sun more than necessary, but keep them under wet moss or in a wet loam puddle during the operation of planting; this is especially a necessity for conifers.

Press the soil firmly around the roots after these have been placed in a natural position. Mulching, if it can be done, is better than watering.

7. The number of trees to be planted per acre is determined (*a*) by the need of preserving the soil humidity: on a poor, dry soil, therefore, (contrary to agricultural usage), more plants are required than on a fresh or moist soil, unless to check the

weed growth on the latter, (*b*) by regard to the quality of the wood: dense growth favors the development of long, straight, clean, cylindrical shafts, (*c*) by regard to amount of wood production: in an open growth the predominant trunks attain greater dimensions, but the total amount of wood per acre is considerably diminished, (*d*) by regard to detrimental influences: in a very dense growth weak plants result, which are more liable to be injured by wind, snow, and even insects, while in a wide planting the growth of grass and weeds deteriorates the soil for wood production.

8. Plant mainly such trees as are indigenous to the climate in which you plant, regard being had to their adaptation to soil conditions. It is not the chemical constitution of the soil, but its physical properties, and especially its depth, looseness, and degree of moisture, which are chiefly to be considered.

9. Always mix or group different kinds together, except perhaps in the case of the shady conifers and, perhaps, the shadiest broad-leaved trees.

SPECIALLY VALUABLE TREES.

An attempt has been made to reduce the number of arborescent species from the 412 constituting the flora of the United States, as given in the Census Report by Professor Sargent, to those which are likely to maintain their position as valuable forest trees; that is to say, those which may, according to our present knowledge, demand the attention of the forester. Such notes of interest to the forest planter as were available have been added.

This list is only preliminary, and may have to be considerably modified and enlarged. I need only refer to the addition of *Catalpa speciosa* to our list of desirable forest trees, which, formerly almost overlooked, was transferred from obscurity to a place among the first order by the late Dr. Warder. Many trees, though at present and in particular localities forming almost the only supply of timber, have been left out on account of their doubtful value as objects of artificial forestry. I mention the mesquit of the Southwestern Territories. The valuable hard-woods of semi-tropical Florida have been entirely omitted, and perhaps some of the conifers of the Pacific slope might have been rightly included in the list. The object of the list being simply to acquaint the practical man with a select number of the more important species which seem to be of value for future forestry, any omissions may be remedied hereafter. The grouping has not been made on botanical grounds, but rather from practical points of view. In the names of the trees the nonpareil bold-faced type denotes that the tree is considered of first importance; the nonpareil title condensed denotes trees in value above those printed in nonpareil roman capitals.

In the naming, the common name has been placed first, somewhat under protest, because the confusion in common names is even worse than in botanical. The first name chosen, because most expressive or most commonly used, will be employed by this Division hereafter to denote the species, in the hope that thus gradually the road to a greater uniformity of common nomenclature may be opened. The botanical nomenclature is that used by Professor Sargent in the census work of 1880, from which also the columns in regard to distribution, size, quality, and uses of wood are mostly made up, but in some cases conflicting opinions of authorities have led to statements differing from those expressed in the census volume. The distribution has been given only in general terms, which for practical purposes may suffice to indicate what climatic conditions seem favorable to the development of the species. The sizes given are either those to which under ordinary circumstances the species often develop, or else the largest as reported in the census volume or elsewhere, the addition mark (+) denoting that larger sizes have been observed. Heavy print or italics call special attention to the most important qualities.

For the column of remarks the standard authorities, often diverging in their views or opinions, have been consulted and personal observations added. This column must naturally be largely tentative, for lack of sufficient special knowledge on the subject. Requirements of soil have been mostly deduced from the natural conditions in which the species is found. This, however, does not always indicate the preference, but only the capability of the species, as, for instance, in the case of the Bald Cypress. Shade-enduring and light-needing are terms which refer chiefly to the capacity of the species for thriving when subjected to the influence of the shade of other trees in their vicinity. This capacity, as stated before, is a relative one and changeable according to site. The indication here given must be understood only as expressing the general tendency, which may be modified under particular conditions.

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Preliminary list of the ninety most important timber trees of the United States.

A. CONIFERS.—(Evergreens and needle-leaved trees, with a few exceptions.) The most valuable forest trees, as well on account of their usefulness as of their forestal effects, due to evergreen foliage of most of them, persistent through several years; most capable of covering extensive areas exclusively, and with deciduous trees most excellent aids in forestry, on account of their habit of growth and their soil-improving qualities; few capable of reproduction by sprouting from the stocks, or practically from cuttings; mostly periodical seeders; persistent growers. Distribution of species climatically confined.

I. PINES.—The most useful Conifers and most important forest trees, mostly of the plain; reaching desirable development in comparatively dry, even barren, situations. Mostly light-needing; tolerably rapid growers; best on light sandy soils with clay subsoil.

Characteristics.—Leaves arranged in twos, threes, or fives in one sheath; cones with thickened scales; seeds almond-shaped, nut-like, of mottled appearance, with their wings only lightly attached; maturing the second year, and preserving germinating power well. Sixty to seventy species, of which thirty-five are indigenous to the United States.

NORTHERN PINES.

Name and size.	Distribution.	Quality and uses of wood.	Remarks.
1. **White Pine**................ (WEYMOUTH PINE.) (*Pinus strobus*, Linn.) Height, 150 feet; diameter, 4 feet +.	Northeastern; wide range, forming forests. Best development in region of the Great Lakes.	Light, soft, not strong, nor durable in contact with the soil; *free from resin and easily worked.* Immense quantities used for *lumber* of different kinds, cabinet-work, timber, shingles, laths, and inferior fuel.	Best on light, sandy, fresh, deep soils, but successful on a large range of soils from dry to moist. Rapid grower; does not endure much shade; hardy, but little tolerant of drouth. The *most important* conifer of the United States; good quality, however, only in centenarians. Is best mixed with deciduous trees; of slow germination; plant one or two-year-old transplanted seedlings.
2. **Red Pine**..................... (NORWAY PINE.) (*Pinus resinosa*, Ait.) Height, 70 feet +; diameter, 2 feet +.	Northern: associated mostly with White Pine. Greatest development in Michigan.	Light, harder and stronger than that of White Pine; elastic, *very durable*, very resinous. Used chiefly for *lumber*, timber, and piles; in the trade, handled together with White Pine.	Soils like those of White Pine; adapted to many soils, but best quality of timber produced in well-drained sands. Extremely hardy; *vigorous* and *rapid* grower. Should be favored in northern and northeastern planting with White Pine and deciduous trees. So far, seed very expensive and difficult to obtain.
3. PITCH PINE.................. (*Pinus rigida*, Miller.) Height, 40 feet +; diameter, 2 feet +.	Northeastern coast...	Light, brittle, harder and stronger than that of White Pine. Employed chiefly for fuel and charcoal, but occasionally for inferior lumber.	Best on fresh to moist sand, but will succeed on dry, barren, sandy soil, and even on wet, cold, swampy ground, or sea-coasts liable to floods. A rapid grower, and when young hardy and indifferent to drought; light-needing; an early seeder; sprouts from the stump; not easily transplanted; best and *easily* propagated from *seed.* **Recommended mainly for *sea-coast* planting.**

Preliminary list of the ninety most important timber trees of the United States—Continued.

Name and size.	Distribution.	Quality and uses of wood.	Remarks.
4. GRAY PINE (SCRUB PINE. PRINCE'S PINE.) (*Pinus Banksiana*, Lambert.) Height, 30 feet +; diameter, 2 feet +.	Northeastern (in United States), forming forests far north. Greatest development north of Lake Superior.	Light, soft, not strong. Employed chiefly for fuel and ties.	More common on sandy, barren soil than in rich loams. Valuable only as first cover for northern pine-barrens. Rapid grower in its youth, and easily handled; very hardy, enduring heat and cold well.
SOUTHERN PINES.			
5. **Long-leaved Pine** (SOUTHERN PINE. YELLOW PINE. GEORGIA PINE. HARD PINE.) (*Pinus palustris*, Miller.) Height, 90 feet +; diameter, 4 feet +.	South Atlantic and Gulf coasts.	Heavy, hard, tough, and very strong; *very durable, very resinous.* Chiefly for *lumber;* ship-building, fencing, ties; good fuel. The *turpentine*, tar, pitch, and spirits of turpentine of United States market derived almost entirely from this tree.	Well-drained, loose, deep sandy loam or gravel. The slow growth of first five years (quasi-endogenous) makes its forestry problematic; development dependent on atmospheric moisture; least shade-enduring of pines. Rare but plentiful seeder; germinates freely; can therefore be propagated by sowing seed in permanent place. Most valuable pine of the South, but for good quality requires long period of growth (two hundred years?).
6. **Short-leaved Pine** (BULL PINE. YELLOW PINE. SPRUCE PINE.) (*Pinus mitis*, Michx.) Height, 90 feet +; diameter, 4 feet +.	Eastern and Southern States; associated mostly with hard-wood trees. Best development in Western Louisiana, Southern Arkansas, and Eastern Texas.	Heavy, hard, strong, and durable. Used chiefly for *lumber*. Very much like that of Long-leaved Pine, to which it is hardly inferior, but yielding no resinous products.	More common on light sandy soil than on low borders of swamps. A rather slow grower; will succeed on the poorest soil. Easily reproduced; good seeder; light-needing. All points taken together, probably, with the following species, the *pine of future* Southern forestry.
7. **Cuban Pine** (SLASH PINE. SWAMP PINE. BASTARD PINE.) (*Pinus Cubensis*, Grisebach.) Height, 75 feet +; diameter, 2 feet +.	Southern and southeastern coast; local in swamps and near water courses. Best development in Eastern Florida.	Heavy, exceedingly hard, very strong, *tough*, and *durable.* Hardly inferior to that of *Pinus palustris*, with which it ranks in Florida. Employed for light construction; yields little resinous matter.	Light sandy soil; somewhat indifferent to drainage. *Rapid grower; easily reproduced;* matures seed yearly; superseding the Long-leaved Pine; light-needing.

8. **Lobl'lly Pine** (OLD-FIELD PINE.) (*Pinus tæda*, Linn.) Height, 100 feet +; diameter, 3 feet +.	Southeastern. Greatest development in Eastern Gulf States.	Light, brittle, not strong nor durable when exposed to the weather. Used principally for fuel, and lumber of an inferior quality; yields *resinous products abundantly*.	Low, moist, or dry sandy soils and abandoned fields. Adapted to a wide range of sites. Rapid grower, *light-needing;* persistent, and plentiful seeder. A useful concomitant of Southern forestry.
9. SPRUCE PINE. (OLD-FIELD PINE OF FLORIDA. CEDAR PINE. WHITE PINE.) (*Pinus glabra*, Walter.) Height, 80 feet +; diameter, 3 feet +.	Southeastern. Best development in Alabama and Mississippi.	Light, *soft*, *easily worked*, brittle, not strong nor durable; resembles that of *Pinus tæda;* not resinous. Employed chiefly for inside work.	Grows on better and moister soils than *Pinus tæda;* Loblolly Pine hummocks and rich bottom-lands. The most rapid-growing pine; shade-enduring.
WESTERN PINES. (Of the many species the true value for forestry is still unknown.)			
10. **Bull Pine** (YELLOW PINE. HEAVY-WOODED PINE.) (*Pinus ponderosa*, Douglas.) Height, 200 feet +; diameter, 12 feet +.	Rocky Mountains to the Pacific, up to high elevations; forming forests. Best developed on western slope of Sierras of Northern and Central California.	Light, brittle, strong; not durable. Employed largely for lumber, mining-timber, ties, and fuel.	Dry, rocky ridges and prairies, sometimes in swamps; but best in deep loamy sand. Vigorous, rapid grower; very hardy, except when quite young. Well adapted to dry, windy, exposed places; therefore worthy of trial on Western prairies. The pine for reforesting southern exposure of the Western mountain regions.
11. **Black Pine** (BULL PINE.) (*Pinus Jeffreyi*, Murray.) Height, 100 feet +; diameter, 4 feet +.	California; eastern slopes of Sierra Nevada above 6,000 feet.	Light, hard, strong. Chiefly for coarse lumber.	Replacing the former species; only for reforestation of the highest mountain slopes. Suffers from drought.
12. FOX-TAIL PINE (HICKORY PINE.) (*Pinus Balfouriana*, Murray.) Height, 50 feet; diameter, 5 feet.	Local—California; above 5,000 feet.	Light, soft, brittle, weak; according to others, hard, tough, very durable.	Dry gravelly slopes of high elevations. Important for reforestation of southern exposures in Rocky Mountains, Pacific slope.

Preliminary list of the ninety most important timber trees of the United States—Continued.

Name and size.	Distribution.	Quality and uses of wood.	Remarks.
13. (VAR. ARISTATA, ENGELM).... Height, 100 feet; diameter, 8 feet.	Local—Rocky Mountains and Southeastern California; above 7,500 feet.	Light, soft, not strong.... In Nevada employed for mining-timber.	Dry gravelly ridges; otherwise as above.
14. SUGAR PINE.... (*Pinus Lambertiana*, Douglas.) Height, 150 feet +; diameter, 10 feet +.	Western Pacific slope.... Best development in Sierras of Central and Northern California above 4,000 feet; lower in Oregon.	Very light; soft, coarse, easily worked.... Lumber for interior finish, cooperage, and woodenware; resembles that of White Pine. Seeds large and edible.	Very rapid grower. Quite hardy in the East.
15. MONTEREY PINE.... (*Pinus insignis*, Douglas.) Height, 80 feet +; diameter, 2 feet +.	Local.... California coast south of San Francisco.	Light, soft, brittle, not strong; according to others, tough and of good repute.	Light well-drained soils, and on drifting sands. Easily propagated; rapid grower.

II. SPRUCES.—Next in importance to the Pines, though wood is less resinous, weaker, and not as durable. Of northern or mountain habitat, in cool situations and moist soils; shade-enduring, and mostly rapid and persistent growers. The Norway Spruce of Europe appears, so far, superior for forestry to the native species.

Characteristics.—Leaves single, rigid, sharp-pointed, four-cornered; bristling mostly all around the twigs. Cones long, hanging, with thin, persistent scales. Seeds resembling those of the pines, but usually smaller, more uniform in color, and angular; mature the first year, and preserve power of germination well. Mostly periodical, but abundant seeders. Crown pyramidal. About twelve species, of which five are indigenous.

Name and size.	Distribution.	Quality and uses of wood.	Remarks.
16. **Black Spruce**.... (RED SPRUCE.) (*Picea nigra*, Link.) Height, 80 feet; diameter, 2 feet +.	Mainly Northeastern; forming forests. Best development north of latitude 53°.	Light, soft, strong.... Used largely for lumber, ship-building, posts, piles, poles, ties; *tougher, stronger*, more *durable*, and *elastic* than that of White Pine, for which it is substituted in floors, rafters, and other building timber; not good fuel.	Light, dry, stony soils; much smaller in cold wet swamps. Best timber produced on southern exposures. Endures less shade than Norway Spruce; rapid grower.

17. ENGELMANN'S SPRUCE.... (WHITE SPRUCE.) (*Picea Engelmanni*, Engelm.) Height, 100 feet +; diameter, 3 feet +.	Western mountain regions and northward; high elevation. Best development in central Rocky Mountain region, between 9,000 and 10,000 feet.	Very light, soft, not strong.... Used chiefly for lumber; bark used in tanning.	Dry, gravelly slopes, 5,000 to 11,500 feet. A tree for reforestation of the highest mountain slopes.
18. **Sitka Spruce**.... (TIDE-LAND SPRUCE.) (*Picea Sitchensis*, Carrière.) Height, 150 feet +; diameter, 6 feet +.	Alaska and Northwestern coast; low elevations.	Light, soft, not strong (according to others strong); superior to that of other native species. Used chiefly as lumber for construction, interior finish, fencing, boat-building, cooperage, woodenware.	Moist soil and climate, at least a moist subsoil, shady situations. *Rapid grower.* Readily propagated from cuttings. Probably hardy in Northeastern and Middle States, in shaded positions.

III. FIRS.—Important to forestry mainly on account of their great shade endurance. Of northern and mountain distribution; still more dependent on moisture of climate, and cool, or at least evenly-tempered situations than the spruces, and in their youth mostly less hardy; usually slow, but persistent growers. Some exotics seem to be of more value than the native species (*Abies Nordmanniana*).

Characteristics.—Leaves single, flat, rather blunt, arranged somewhat comb-like on the twigs. Cones cylindrical, standing erect on the branches; scales thin, and falling away when mature; seeds triangular, partly inclosed by a more or less persistent wing; mature first year, but do not preserve their power of germination well. Frequent and abundant seeders. Crown conical. About eighteen species, of which eight are indigenous.

Name and size.*	Distribution.	Quality and uses of wood.	Remarks.
19. WHITE FIR.... (BALSAM FIR. BLACK BALSAM.) (*Abies concolor*, Lindl. and Gordon.) Height, 100 feet +; diameter, 4 feet +.	Southwestern mountains and Pacific slope; high elevations. Best development in Sierras of California.	Very light, soft, not strong.... Occasionally manufactured into lumber, butter-tubs, and used for other domestic purposes.	Moist slopes and cañons, between 3,000 and 9,000 feet; cool and shady situations.
20. BALSAM FIR.... (BALM OF GILEAD FIR.) (*Abies balsamea*, Miller.) Height, 70 feet +; diameter, 2 feet.	Northeastern....	Very light, soft; not strong nor durable in contact with the soil.	Cold, damp woods and swamps. Rapid grower. Valuable only as undergrowth, or as nurse, and in imperfectly drained situations.
21. **Great Silver Fir**.... (WHITE FIR.) (*Abies grandis*, Lindl.) Height, 300 feet; diameter, 5 feet +.	Northwestern coast.... Best development in Western Washington and Oregon.	Light, soft, not strong.... For lumber, cooperage, etc.; with Douglas Spruce forming the bulk of Pacific coast lumber.	Bottom-lands; rich moist soil. Very hardy and rapid grower; affected less by late frosts and occasional droughts than most firs. Probably commendable for planting in Eastern and Middle States.

Preliminary list of the ninety most important timber trees of the United States—Continued.

Name and size.	Distribution.	Quality and uses of wood.	Remarks.
22. RED FIR (NOBLE SILVER FIR.) (*Abies nobilis*, Lindl.) Height, 300 feet +; diameter, 9 feet +.	Northwestern coast; wide range; forms extensive forests. Best development in coast ranges from Columbia River to Northern California.	Light, hard, strong	Probably hardy east of the Rocky Mountains, with proper protection.
23. LOVELY SILVER FIR (*Abies amabilis*, Forbes.) Height, 100 feet +; diameter, 4 feet. According to others, 250 feet high and 5 feet in diameter.	Northwestern United States. Best development on mountains south of Columbia River; 3,000 to 4,000 feet.	Light, hard, not strong	Gravelly soils. Will probably prove hardy in Eastern States.

IV. BASTARD SPRUCES.—Under this name may be grouped the Hemlocks and Douglas Spruce, formerly classed with the spruces and firs proper. Mostly of northern distribution, and therefore best adapted to cool moist situations; enduring partial shade. Some very rapid growers.

Characteristics.—Leaves single, flat, linear, with distinct stalks (petioles), somewhat comb-like in their arrangement on the twigs. Cones usually small, with thin scales, hanging from the ends of the branches. Seeds, partly inclosed in a persistent wing, resemble those of the firs, but of smaller size; mature the first year, do not keep well; low percentage of germination. Branches pendant; crown spindle-like in form. Two genera, comprising seven species, five of which are indigenious.

Name and size.	Distribution.	Quality and uses of wood.	Remarks.
24. **Douglas Spruce** (RED FIR. YELLOW FIR. OREGON PINE.) (*Pseudotsuga Douglasii*, Carrière.) Height, 300 feet +; diameter, 10 feet +.	Rocky Mountain region to Pacific; wide range; forming forests. **Best development in Western Oregon and Washington.**	Rather heavy, hard, strong, durable. **Used chiefly for lumber, ties, piles, and fuel; bark employed in tanning.**	**Accommodates itself to many soils, but prefers a deep and moist cool and well drained one; succeeds well on a dry, slaty soil, and on sand dunes and exposed situations.** **Surpasses almost all of the conifers in the *rapidity* of its growth, and endures *drought* better than most of them; *shade-enduring*.** **One of the largest and most important forest trees of the West. For Eastern planting seed should be procured from Colorado or Montana. Repairs damage very readily.**

25. **Hemlock** .... (*Tsuga Canadensis*, Carrière.) Height, 100 feet; diameter, 4 feet +.	Northern and Eastern States, forming forests. Best development probably in Canada.	Light, soft, rather strong, not durable; coarse-grained, and peculiar for holding nails well. Usually manufactured into coarse lumber; used also for ties, construction, etc. The *tan-bark* of this species is the principal one used in Northern States.	Light, alluvial loam, well-drained, but cool and moist situations. Slow grower when young, but tolerably rapid after four or five years; does not endure much shade. Natural propagation in its present areas most urgently needed.
26. **Western Hemlock** .... (*Tsuga Mertensiana*, Carrière.) Height, 180 feet +; diameter, 9 feet +.	Northwestern, between 1,000 and 4,000 feet. Best development in Western Oregon and Washington.	Rather heavy, hard, not strong .... Employed somewhat for coarse lumber. The bark supplies an important demand for tan-bark on the northwest coast.	A substitute for the above species on the Pacific coast. An exceedingly rapid grower, even on poor soils.

V. DECIDUOUS-LEAVED CONIFERS.—Though botanically not classed together, yet in forestry they may be considered allied, as the yearly fall of leaves is a soil-improving feature, while the absence of foliage during the winter and early spring distinguishes them from the evergreens, and their extreme need of light requires similar forest management. The Larches are of Northern or mountain habitat; and the Bald Cypress of local Southern distribution, but all are adapted to different situations. The European Larch probably surpasses the Northeastern Tamarack in every respect.

Characteristics.—Larches: Leaves in clusters, slender and soft. Cones small, egg-shaped, with thin scales; seeds small, triangular, nut-like in shape; mature the first year. Frequent and prolific seeders; seeds keep well, but of low percentage of germination.

In the Bald Cypress, leaves single, sharp-pointed, very small and scanty, comb-like in arrangement on the young twigs. Cones ball-like, with thick, woody scales, falling apart when mature; seeds irregularly triangular-shaped, with hard, thick, wood-like shell; mature yearly; abundant, and keep well.

Name and size.	Distribution.	Quality and uses of wood.	Remarks.
27. **Bald Cypress** .... (*Taxodium distichum*, Rich.) Height, 150 feet; diameter, 12 feet.	Southeastern, forming forests in swamps and pine-barren ponds.	Light, soft, not strong; *very durable* in contact with the soil. Used largely in manufacture of *lumber*, *shingles*, for ties, posts, cooperage.	Indifferent to imperfect drainage and flooding, but capable of rapid growth on well-drained, moist, sandy soils, and hardy as far north as latitude 39° and 40°, and even on Western prairies. Positively light-needing. To be recommended for extensive planting in favorable situations, where even superior lumber may be expected.
28. **Tamarack** .... (BLACK LARCH. HACKMATACK.) (*Larix Americana*, Michx.) Height, 100 feet; diameter, 2 feet +.	Northeastern (in United States) .. Best development probably north of the United States boundary.	Heavy, hard, very *strong*; *durable* in contact with the soil. Employed largely for upper knees of vessels, *ship-timbers*, posts, *ties*, *telegraph-poles*, and occasionally for lumber.	North of United States boundary, found on moist uplands; South (in United States), in cold, wet swamps; but probably of more value when grown on deep, moist, well-drained soils, in cool situations. Rapid and persistent grower; light-needing. Deserves attention in Northern forestry, but only in mixed growths.
29. **Western Larch** .... (TAMARACK.) (*Larix occidentalis*, Nutt.) Height, 100 feet +; diameter, 4 feet +.	Northwestern; elevations between 2,500 and 5,000 feet. Best development in valley of Flathead River, Montana.	Heavy, very hard, strong; durable in contact with the soil. Chiefly for posts, ties, fuel, and occasionally for lumber.	An important tree as a Western representative of the foregoing species.

Preliminary list of the ninety most important timber trees of the United States—Continued.

VI. CYPRESS FAMILY.—Under this head may well be grouped, both botanically and forestally considered, the Junipers and so-called Cedars, to which can be added the California redwoods. Characterized mostly by the shingle-like arrangement of their small, scaly leaves, the small, roundish fruit (a cone, or berry-like), and by the usually upright habit of the branches and scanty fall of leaves.

Their great shade-enduring qualities make them valuable adjuncts to forestry, otherwise of only secondary importance. Of the many species contained in seven genera but fourteen are found in the United States.

Name and size.	Distribution.	Quality and uses of wood.	Remarks.
30. **Red Cedar** .... (SAVIN.) (*Juniperus Virginiana*, Linn) Height, 60 feet +; diameter, 4 feet +.	Gulf to Northern States, Rocky Mountains (Colorado) to British Columbia; wide range. Best development in valley of Red River, Texas.	*Light, soft*, brittle, fine-grained; very *durable* in contact with the soil. Fence-posts, ties, cabinet-work, and almost entirely for wood of lead *pencils*.	Prefers a mild climate; deep swamps, borders of streams, ridges, hills; will thrive on a rather dry, loose soil. Easily propagated from seed and cuttings. Perhaps the most important conifer for Southwestern prairie planting, enduring drought and partial shade. Tolerably rapid grower.
31. **White Cedar** .... (*Chamæcyparis sphæroidea*, Spach.) Height, 80 feet +; diameter, 3 feet +.	Atlantic and Gulf States to Central Mississippi. Most abundant and best developed in Virginia and North Carolina.	Light, soft, fine-grained; *very durable* in contact with the soil. Used principally for shingles, ties, posts, cooperage, boat-building, woodenware.	Always in low, marshy, or wet ground, where it thrives well. Rapid grower; endures great shade; easy to propagate from seed or cuttings.
32. ARBOR-VITÆ .... (WHITE CEDAR.) (*Thuya occidentalis*, Linn.) Height, 50 feet +; diameter, 4 feet +.	Northeastern	Light, soft, brittle; not strong; *very durable* in contact with the soil. Used chiefly and largely for posts, ties, and shingles.	Will grow well in any soil not too wet or too stiff. Rapid grower: easily propagated; desirable for undergrowth and to fill out places where other trees fail to come.
33. **Canoe Cedar** .... (RED CEDAR. YELLOW CEDAR.) (*Thuya gigantea*, Nutt.) Height, 130 feet +; diameter, 9 feet +.	Northwestern	Light, soft, brittle, not strong; very durable in contact with the soil. Used principally for interior finish, cabinet-making, shingles, cooperage, fencing. Indians of Northwest employ it exclusively for making canoes.	Like the above species, on Pacific coast.

34. **California White Cedar.** (BASTARD CEDAR. POST CEDAR. INCENSE CEDAR.) (*Libocedrus decurrens*, Torr.) Height, 100 feet +; diameter, 6 feet +.	Southwestern Pacific slope; between 3,000 and 8,500 feet.	Light, soft, brittle, not strong; very durable in contact with the soil; but according to others not at all so. Extensively used for fencing, posts, water-flumes, interior finish, furniture, shingles, and laths.	Slopes and valleys, in well-drained soils. Rapid grower; of excellent appearance. In the East probably adapted only to Southern States; hardy at Washington, D. C.
35. **Redwood** .... (*Sequoia sempervirens*, Endlicher.) Height, 300 feet +; diameter, 20 feet +.	California; local; western slopes.	Light, soft, brittle, not strong; very durable in contact with the soil. The chief and most valuable building timber of the Pacific coast. In California used almost entirely for shingles, posts, ties, poles, telegraph-poles, water-tanks, tubs, etc.	Low, moist, well-drained situations and damp climate; not on dry hillsides. Vigorous and persistent grower; shade-enduring; sprouts from the stump. Highly important for California forestry; perhaps also for that of Southern States.
36. BIG TREE OF CALIFORNIA. (*Sequoia gigantea*, Decaisne.) Height, 350 feet +; diameter, 35 feet +.	California; very local and isolated	Light, soft, brittle, weak; exceedingly durable in contact with the soil. Once locally used for lumber, fencing, shingles, construction, etc.	Moist situations, between 4,000 and 6,000 feet. Probably only of historical interest.

B. BROAD-LEAVED TREES.—(With few exceptions, deciduous-leaved trees.) A strictly practical or botanical classification in large groups has not been attempted, but a sequence within botanical relations, and an arrangement according to the nature of the seed has been more or less observed, placing first the acorn- and nut-bearing trees, next, those with hard, wingless seeds, and lastly, those with soft and winged seeds.

Name and size.	Distribution.	Quality and uses of wood.	Remarks.
37. **White Oak** .... (*Quercus alba*, Linn.) Height, 130 feet +; diameter, 6 feet +.	North Central, Central, and Eastern States. Best development on western slopes of Alleghany Mountains and valley of Ohio River.	Heavy, hard, strong, tough, durable in contact with the soil. Chiefly for ship-building, construction of all kinds, *cooperage*, carriage and wagon stock, *agricultural implements*, fencing, posts, ties, *piles*, cabinet-making, interior finish, coarse lumber, and fuel.	Grows well on a great variety of soils, but best on deep, moderately moist, well-drained loamy sand, and in warm situations. Slow but persistent grower; light-needing, capable of enduring shade but not with advantage. Most valuable of the American oaks.
38. **Basket Oak** .... (SWAMP CHESTNUT OAK. COW OAK.) (*Quercus Michauxii*, Nutt.) Height, 100 feet +; diameter, 3 feet +.	Southeastern .... Best development on the rich bottom lands of Southeastern Arkansas and Louisiana.	Very heavy, hard, tough, and very strong; very durable in contact with the soil. Largely employed in the manufacture of agricultural implements, wheel-stocks, cooperage, baskets, fencing, and fuel.	Moist rich soil; will endure flooding. The most valuable of the white oaks for the Gulf States.

Preliminary list of the ninety most important trees of the United States—Continued.

Name and size.	Distribution.	Quality and uses of wood.	Remarks.
39. **Burr Oak** (MOSSY-CUP OAK. OVER-CUP OAK.) (*Quercus macrocarpa*, Michx.) Height, 100 feet +; diameter, 4 feet +.	North Central, Central, and Northeastern United States; extends farthest West and Northwest of any of the Eastern oaks.	Heavy, hard, strong, tough; most *durable* in contact with the soil of any of American oaks. Employed for the same purposes as that of White Oak; more durable, but porous.	Requires better soil than White Oak; more shade-enduring. A Western substitute for White Oak, and especially recommended for prairie planting.
40. **Post Oak** (IRON OAK.) (*Quercus obtusiloba*, Michx.) Height, 60 feet +; diameter, 3 feet +.	East of the Rocky Mountains	Very heavy, hard; very durable in contact with the soil. Chiefly for fencing, ties, fuel, and occasionally for carriage-stock, cooperage, and other construction.	Well-drained gravelly uplands, clay barrens, and poor sandy loams. Recommended for Western planting.
41. **Chestnut Oak** (ROCK CHESTNUT OAK.) (*Quercus prinus*, Linn.) Height, 80 feet +; diameter, 3 feet +.	Northeastern. Best development in southern Alleghany Mountains.	Heavy, hard, strong, rather tough; durable in contact with the soil. Less valuable than the foregoing species. Used chiefly for fencing and ties. Valued principally for *tan-bark*.	For planting on rocky banks and hillsides; never in any but well-drained situations.
42. **Live Oak** (*Quercus virens*, Ait.) Height, 60 feet +; diameter, 5 feet +.	Southern. Greatest development in Southern Atlantic States.	Very heavy, hard, *strong*, tough, and durable. Once largely employed in ship-building, but now only occasionally; somewhat for tool-stock.	Warm loamy soil, retentive of moisture, and free from overflow. Most *rapid* grower *of all the oaks; most shade-enduring;* evergreen foliage. Especially desirable for Southern forestry.
43. CALIFORNIA LIVE OAK (MAUL OAK. VALPARAISO OAK.) (*Quercus chrysolepis*, Liebm.) Height, 80 feet +; diameter, 5 feet +.	Pacific States, 3,000 to 8,000 feet elevation.	Very heavy, hard, tough; very strong. Employed considerably in the manufacture of agricultural implements, wagons, etc.	Warm, dry, sunny exposures. Most valuable of the Pacific oaks. Foliage evergreen.

44. CALIFORNIA CHESTNUT OAK. (TAN-BARK OAK. PEACH OAK.) (*Quercus densiflora*, Hooker & Arnott.) Height, 60 feet +; diameter, 2 feet +.	Pacific coast. Best development in redwood belt on California coast.	Heavy, hard, strong; inferior to other white oaks; valued chiefly for tan-bark.	Well-drained, rich soils. Shade-enduring. Foliage evergreen.
45. RED OAK (BLACK OAK.) (*Quercus rubra*, Linn.) Height, 100 feet +; diameter, 4 feet +.	East of Rocky Mountains Most northerly of Atlantic oaks. Best development in Massachusetts.	Heavy, hard, strong; inferior in quality to white oaks. Largely employed for clapboards, cooperage, manufacture of chairs, and to some extent for interior finish. Important for *tan-bark*.	Thrives in all soils, except an undrained one. Among the most *rapid* in growth of all the oaks. Vigorous *sprouter* from stump; of importance for tan-bark coppices.
46. BLACK OAK (YELLOW-BARK OAK. YELLOW OAK. QUERCITRON OAK.) (*Quercus tinctoria*, Bart.) Height, 80 feet +; diameter, 3 feet +.	East of longitude 96°, United States. Best development in North Atlantic States.	Heavy, hard, strong, not tough Used somewhat for cooperage, agricultural implements, and for construction. Superior to White Oak for some purposes. Important for tan-bark.	Gravelly uplands; poorer soils than White Oak requires. Rapid grower.
47. SPANISH OAK (RED OAK.) (*Quercus falcata*, Michx.) Height, 70 feet +; diameter, 4 feet +.	Central, Southeastern, and Southern. Best development in South Atlantic and Gulf States.	Heavy, very hard, and strong, not durable. Used for cooperage, construction, and fuel. Important for tan-bark.	Dry, barren soils. Rapid grower.
48. WATER OAK (DUCK OAK. POSSUM OAK. PUNK OAK). (*Quercus aquatica*, Walter.) Height, 70 feet +; diameter, 3 feet +.	Central, Southern, and Southeastern. Greatest development in Eastern Gulf region.	Heavy, hard, strong Chiefly for fuel; also for cooperage.	Heavy undrained soil. Exceedingly rapid grower.
49. **Beech** (*Fagus ferruginea*, Ait.) Height, 100 feet +; diameter, 3 feet +.	East of Mississippi and Missouri Rivers. Best development probably on "bluff" formations of lower Mississippi basin.	Heavy, hard, strong; not durable when exposed to dryness and moisture, but exceedingly so when kept constantly under water. Extensively used in the manufacture of chairs, shoe-lasts, plane-stocks, handles, etc.; an excellent fuel.	Fresh, rich, but not necessarily a deep soil; limestone soils. For rocky, exposed situations. Rapid grower and *enduring shade* exceedingly well, a fact which renders it one of the most valuable aids in forestry.

Preliminary list of the ninety most important trees of the United States—Continued.

Name and size.	Distribution.	Quality and uses of wood.	Remarks.
50. **Chestnut** .... (*Castanea vulgaris*, var. *Americana*, A. D C.) Height, 90 feet +; diameter, 10 feet +.	Northeastern United States .... Best development on western slopes of Alleghany Mountains.	Light, soft, not strong; *durable* in contact with the soil; exceedingly so in situations alternately wet and dry. Chiefly for cabinet-work, ties, posts, and fencing. Edible fruit of commercial value.	*Well-drained* gravelly soils; succeeds on rocky hillsides with soil of sufficient looseness and depth; on northern and eastern exposures; will thrive on rather poor sand, but not on limestone. Exceedingly *rapid* grower; moderately shade-enduring; most vigorous and *persistent sprouter* from the stump; *large yield per acre*.
51. **Black Walnut** .... (*Juglans nigra*, Linn.) Height, 100 feet +; diameter, 6 feet +.	Northeastern, Central, and Southeastern. Best development on southern slopes of Alleghany Mountains, and in bottom-lands of Southwestern Arkansas and Indian Territory.	Heavy, hard, strong, very durable in contact with the soil. Extensively used for *cabinet-work*, gunstocks, and interior finish.	Deep, loose, fresh to moist, warm, and sandy loam; will grow in a dry and compact soil, but not in a wet one. Hardy and rapid grower, especially in height; but only centenarians produce first-class quality of lumber. Good sprouter from the stump. Not recommended for arid or sub-arid regions or for uplands.
52. **Butter Nut** .... (WHITE WALNUT.) (*Juglans cinerea*, Linn.) Height, 60 feet +; diameter, 2 feet +.	Northeastern .... Best development in basin of Ohio River.	Light, soft, durable, not strong .... Employed chiefly for cabinet-work and interior finish.	Prefers a deep, rich, *cool* loam; suited to cooler sites and colder climate than the foregoing species. Rapid grower when young.
53. **Shell-bark Hickory** ...... (SHAG-BARK HICKORY.) (*Carya alba*, Nutt.) Height, 100 feet +; diameter, 3 feet +.	Eastern United States; wide range. Best development west of the Alleghany Mountains.	Very heavy, very hard, strong, *tough*, *elastic*; *not durable* in contact with the soil or exposed to the weather. Used chiefly for agricultural implements, *carriage-stock*, ax and tool-handles, baskets, etc.; best fuel.	Deep, fresh soil; a compact soil not objectionable; not on poor, dry, or wet soils. At first slow, but afterward rapid grower; sprouts well from the stump. Moderately shade-enduring. Somewhat liable to frost.
54. **Bitter Nut** .... (PIG NUT. SWAMP HICKORY.) (*Carya amara*, Nutt.) Height, 70 feet +; diameter, 2 feet +.	Eastern United States; wide range.	Heavy, rather hard, strong, tough; less valuable than that of Shell-bark Hickory. Largely for ox-yokes, hoops, and fuel.	To replace Shell-bark Hickory on low, moist, or wet ground. Good sprouter from the stump. Less liable to frost than Shell-bark Hickory, but more subject to the ravages of insects.

55. **Mocker Nut** (BULL NUT. KING NUT. BLACK HICKORY. BIG-BUD HICKORY. WHITE-HEART HICKORY.) (*Carya tomentosa*, Nutt.) Height, 90 feet; diameter, 3 feet +.	Eastern United States; wide range. Most abundant, and generally distributed in the Southern States.	Very heavy, hard, tough, strong. Used for much the same purposes as that of Shell-bark Hickory, very variable, according to site; resembling Shell-bark Hickory.	To replace Shell-bark Hickory on poorer and drier soils; will succeed even on *barrens*. Good sprouter from the stump, but slow grower; liable to attacks of insects.
56. **Big Shell-Bark Hickory** (BOTTOM SHELL-BARK.) (*Carya sulcata*, Nutt.) Height, 70 feet +; diameter, 3 feet +.	Central United States; local.	Like Shell-bark Hickory and employed for much the same purposes.	Rich, deep soil. Climatically confined.
57. PECAN (ILLINOIS NUT.) (*Carya olivæformis*, Nutt.) Height, 75 feet +; Diameter, 2 feet +.	Southwestern. Best development in Arkansas and Indian Territory.	Heavy, hard, brittle; not strong; inferior to that of Shell-bark Hickory. Used chiefly for fuel. Edible *nuts* an important article of commerce.	Deep, rich bottom-land. Rapid grower. For Southwestern planting. More valuable for production of fruit than for timber purposes.
58. **Wild Black Cherry** (RUM CHERRY.) (*Prunus serotina*, Ehrhart.) Height, 90 feet +. diameter, 3 feet +.	Eastern; wide range.	Rather heavy, hard, strong. Of light-red color. Chiefly for *cabinet-work* and *interior finish*.	Adapted to almost any soil and situation; best in deep, well-drained soil; will succeed also on dry soil. Very rapid grower, very soon reaching a useful size for cabinet-wood. Endures considerable *shade*. The *wide range of sites* to which it is adapted, its rapid growth, and shade place it among the most valuable forest trees of the United States, especially for Western planting. Not infected by caterpillars in forest plantations.
59. SWEET GUM (LIQUIDAMBER. RED GUM. STAR-LEAVED GUM. BILSTED.) (*Liquidambar Styraciflua*, Linn.) Height, 100 feet +; diameter, 3 feet +.	Southeastern. Greatest development in basin of Mississippi River.	Rather heavy and soft; not strong nor durable when exposed to the weather. Manufactured into lumber, clapboards, and coarse boards, for cabinet-work, veneering, etc.	Succeeds on a great variety of soils—light, dry, sandy and soils retentive of moisture. Rapid grower.

Preliminary list of the ninety most important trees of the United States—Continued.

Name and size.	Distribution.	Quality and uses of wood.	Remarks.
60. **Black Locust**	Southern	Heavy, very hard and strong; very *durable* in contact with the soil.	Poor, loose sands give best quality of timber; not succeeding well in compact soils, but will thrive on a thin one, and grows quickest on a rich sandy loam.
(LOCUST. YELLOW LOCUST.)	Alleghany Mountains; local; but by cultivation widely distributed east of Rocky Mountains.	Employed largely for *fence posts*, in turnery, construction, treenails, etc.	Very *rapid* grower while young; *light-needing; persistent* and *vigorous sprouter* from the roots. To be only sparingly dispersed among shady companions, which will afford protection against the attacks of borers.
(*Robinia pseudacacia*, L.)			Easily propagated from seed, also by cuttings, suckers, and stakes. For short rotations and coppice management.
Height, 75 feet +; diameter, 3 feet +.			
61. **Honey Locust**	Central	Heavy, hard, strong; very *durable* in contact with the soil.	Low, rich bottom-land; rarely on high, dry, sterile hills.
(SWEET LOCUST. HONEY SHUCKS. THREE-THORNED ACACIA. BLACK LOCUST.)	Best development in bottom-land of lower Ohio River basin.	For *fence-posts*, rails, hubs, construction, etc.	Very *rapid grower; light-needing*.
(*Gleditschia triacanthos*, Linn.)			*Easily* grown from seed, but not from cuttings. Less liable to insect ravages; otherwise to be treated similar to Black Locust, which it is recommended to replace in Southern localities.
Height, 90 feet +; diameter, 3 feet +.			
62. HACKBERRY	Northern and east of Mississippi River.	Heavy, rather soft, not strong; difficult to split.	Will grow tolerably well on the most barren and poorest soils, but best in a fertile one, cool and moist, where it is of rapid growth; usually slow at first.
(SUGAR-BERRY. NETTLE TREE)	Best development in basin of Mississippi River.	Employed chiefly for fencing, but occasionally in the manufacture of cheap furniture.	In Western planting recommended only as an adjunct in partial *shade*.
(*Celtis occidentalis*, Linn.)			
Height, 100 feet +; diameter, 4 feet +.			
63. RED MULBERRY	East of longitude 98°	Rather heavy, hard, strong, and very durable.	Deep, rich loam; endures shade.
(*Morus rubra*, Linn.)	Best development in basins of lower Ohio and Mississippi Rivers.	Largely employed for fence-posts, in cooperage, snaths and other tool-stock, boat-building, etc.	For Southwestern planting.
Height, 60 feet +; diameter, 2 feet +.			
64. LARGE-FLOWERED MAGNOLIA.	Southern and Gulf States	Heavy and soft, not strong; very white. Suitable for cabinet-work and interior finish.	Cool, moist hummocks, with rich, deep, loose soil.
(SOUTHERN EVERGREEN. BIG LAUREL. BULL BAY.)	Best development along Mississippi in Gulf region.		Not hardy in Northern States; for strictly Southern climate.
(*Magnolia grandiflora*, Linn.)			
Height, 70 feet +; diameter, 3 feet.			

65. **Tulip Tree** .... (WHITE WOOD. YELLOW POPLAR.) (*Liriodendron tulipifera* L.) Height, 150 feet +; diameter, 9 feet +.	Eastern.......................... Greatest development in valley of lower Wabash River, and on Western slope of Alleghany Mountains in Tennessee and North Carolina.	Light, soft, not strong, nor very durable... Manufactured into *lumber* for interior finish, clapboards, shingles, cheap furniture; pumps, wooden ware, boat-building.	Deep, light, loamy, sandy, or clayey soils, in cool, moist situations. Tolerably rapid and persistent grower. Very light-needing; hardy. Poor seeder, and low percentage of germination; seed liable to lie over. Fair sprouter from stump. One of the largest and most valuable of the deciduous soft woods.
66. **Western Catalpa** .... (*Catalpa speciosa*, Warder.) Height, 80 feet +; diameter, 4 feet +.	South Central .... Best development in valley of lower Wabash River.	Light, soft, not strong; *very durable* in contact with the soil. Employed chiefly for *ties*, *posts*, rails; suitable for interior finish.	Adapted to a great variety of soils; best on low, rich bottom-lands. Very rapid grower; sprouts vigorously from the stump; *shade-enduring*. Good seeder and keeper. Readily propagated from seed, cuttings, and layers. Of somewhat straggling habit, a feature which is corrected by planting densely with other species, *i. e.*, either quicker-growing or foregrown, light-foliaged, or equally fast-growing and shady—suitable ones, Black Locust, Black Cherry—Desirable tree for Western planting.
67. OSAGE ORANGE............ (BOIS D'ARC.) (*Maclura aurantiaca*, Nutt.) Height, 50 feet +; diameter, 2 feet.	South Central .... Best development probably in valley of Red River, Indian Territory.	Heavy, very hard and *strong*, flexible; very *durable* in contact with the soil. Chiefly for fence-posts, ties, wheel-stock, paving-blocks.	Best in a moist loam, but adapted to other soils. Dependent on warm climate; medium but not persistent grower; sprouts well from the stump; somewhat shade-enduring. Good seeder and easily propagated. Requires much care to produce desirable timber; and, except for Southwestern planting, questionable as a desirable forest tree.
68. **White Ash** .... (*Fraxinus Americana*, Linn.) Height, 100 feet +; diameter, 5 feet +.	Eastern; wide range .... Best development in lower Ohio basin.	Heavy, hard, *strong*, *very elastic*; old timber brittle. Very valuable. Employed chiefly in the *manufacture* of agricultural implements, carriages, handles, oars, interior finish, cabinet-work, and flooring.	Depth, looseness, and moisture of soil of most importance. Best in moist atmosphere of northern and eastern exposures. Will succeed in wet and compact soil if well-drained, but not in a light and dry one. Rapid grower; light-needing, thinning out rapidly, and therefore requiring shady, slower-growing companions. Vigorous and persistent sprouter from the stump. Poor seeder; seed not easily kept, tending to lie over. Liable to attacks of borer and to frost when young. On account of its demand on the humidity of the soil and its extensive root system to satisfy this demand, a dangerous companion to other trees; therefore requiring careful management.

Preliminary list of the ninety most important timber trees of the United States—Continued.

Name and size.	Distribution.	Quality and uses of wood.	Remarks.
69. **Black Ash** .... (HOOP ASH. GROUND ASH.) (*Fraxinus sambucifolia*, Lam.) Height, 90 feet +; diameter, 3 feet +.	Northern and Northeastern States. The most northerly of the ashes.	Rather heavy, rather soft, tough, *elastic*, not very durable when exposed. Lately much used for interior finish and cabinet-work, fencing, barrel hoops, baskets, and fuel.	Soils like those for *F. Americana*, but *indifferent to drainage*, and more dependent on moisture; therefore well adapted to undrained situations in cool climate; otherwise like *Americana*.
70. **Green Ash**.................... (*Fraxinus viridis*, Michx. f.) Height, 50 feet +; diameter, 1½ feet +	Western States east of Rocky Mountains and South.	Heavy, hard, strong, brittle .... Often employed for same purpose as that of White Oak, but inferior to it in quality.	Less dependent on humidity of soil than the White Ash, but prefers a deep, cool, moist soil. Rapid but not persistent grower. Seed germinates readily. The ash for Western planting.
71. **Blue Ash**....................... (*Fraxinus quadrangulata*, Michx.) Height, 70 feet +; diameter, 2 feet +	Central States.................. Best development in basin of lower Wabash River.	Heavy, hard, brittle; as valuable as any of the ashes, and *most durable* of all when exposed to alternate dryness and moisture. Used for much the same purposes as that of White Ash, but principally in *carriage-making* and flooring.	Less dependent on moisture than other ashes; prefers a rich, deep, moist soil. Recommended for Western planting.
72. OREGON ASH .... (*Fraxinus Oregana*, Nutt.) Height, 60 feet +; diameter, 1½ feet +	Northwestern coast .... Best development in bottom-lands of Southwestern Oregon.	Rather heavy, sometimes brittle, not strong; similar to that of White Ash. Employed chiefly in the manufacture of furniture, carriage and wagon frames, cooperage, fuel.	Moist soils and climate.
73. **Sugar Maple**............... (HARD MAPLE. SUGAR TREE.) (*Acer saccharinum*, Wangh.) Height, 100 feet +; diameter, 4 feet +.	Eastern .... Best development in region of the Great Lakes and Northwest.	Heavy, *hard*, *strong*, tough; not durable when exposed to the weather. Employed chiefly in the *manufacture* of furniture, shoe-lasts and pegs, saddle-trees, turnery, interior finish, flooring; in ship-building, for keels, keelsons, shoes; *excellent fuel*. The "bird's-eye" and "curled" maple of this species are much prized in cabinet-making. Furnishes the maple sugar of commerce.	Best on moderately deep, loose, well-drained, strong, loamy, and calcareous soil, in moist, cool position; will grow also on stiff clay, if not too wet, and on stony hillsides, if not too dry. Tolerably rapid and persistent grower; moderately shade-enduring; does not sprout well from the stump. Not well adapted to dry regions.

74. **Silver Maple** (WHITE MAPLE. SOFT MAPLE.) (*Acer dasycarpum*, Ehrh.) Height, 90 feet +; diameter, 4 feet +.	Eastern (United States). Best development in basin of lower Ohio River.	Rather heavy, soft, brittle, not very strong, nor durable when exposed to the weather or soil. Used in the manufacture of furniture, flooring, for fuel. Yields a good quality of maple sugar.	Adapted to a variety of soils and climates, but best on rich, moist soil. *Very rapid* but not persistent grower; light-needing; sprouts vigorously from the stump; liable to injury from winds; comparatively free from insects. Especially recommended for Western planting.
75. **Red Maple** (SOFT MAPLE. WATER MAPLE. SWAMP MAPLE.) (*Acer rubrum*, Linn.) Height, 90 feet +; diameter, 3 feet +.	Eastern Greatest development in valleys of Lower Wabash and Yazoo Rivers.	Slightly heavier and harder than that of *Silver Maple*; not strong nor durable; inferior to that of *Sugar Maple*, but superior to *Silver Maple*. Used chiefly for cabinet-making, in turnery, for woodenware, gun-stocks, light fuel.	Best on low, wet soils, but will thrive in moderately dry situations. Rapid but not persistent grower; endures more *shade* than *A. dasycarpum*; sprouts vigorously from the stump. Usefulness in dry climates questionable.
76. **Oregon Maple** (CALIFORNIA MAPLE. BROAD-LEAVED MAPLE.) (*Acer macrophyllum*, Pursh.) Height, 90 feet +; diameter, 4 feet +.	Pacific slope. Best development on rich bottom-lands of Southern Oregon.	Rather light, hard, strong; said to be one of the best and most valuable woods of Pacific coast. In Oregon, employed largely in the manufacture of furniture, ax and broom handles, snow-shoe frames, etc. The "curled" wood of this species is highly prized in cabinet-making.	Rich bottom-lands. Rapid grower in moist climate. Important on the Pacific slope.
77. BOX-ELDER (ASH-LEAVED MAPLE.) (*Negundo aceroides*, Moench.) Height, 50 feet +; diameter, 2 feet +.	East of Rocky Mountains, rather Southern and Western. Best development in valleys of Wabash and Cumberland Rivers.	Light, soft, not strong; inferior. Manufactured chiefly into paper-pulp, woodenware, and used somewhat in cooperage and for interior finish, fuel, etc.	Best on low, rich ground, but will succeed on upland. Rapid but not persistent grower; sprouts well from the stump; hardy. *Easily propagated.* For forestry purposes, important only as *nurse* and soil-cover, especially in Western planting.
78. **White Elm** (AMERICAN ELM. WATER ELM.) (*Ulmus Americana*, Linn.) Height, 100 feet +; diameter, 6 feet +.	East of the Rocky Mountains. Probably attains its best developments near its northern limits.	Heavy, hard, strong, very *tough*, but not durable; inferior; often difficult to split. Employed principally for wheel and chair stock, coarse lumber, flooring, cooperage, and fuel.	Adapted to a great variety of soils, but best on a rich, loose, moist one; requires less moisture than the ashes; bears occasional flooding. Rapid and persistent grower; sprouts well; endures moderate shade. Important in forestry mainly as a *nurse* and for soil-cover. Recommended for Western planting.
79. SLIPPERY ELM (RED ELM. MOOSE ELM.) (*Ulmus fulva*, Michx.) Height, 60 feet +; diameter, 2 feet +.	Northern, Atlantic, and Gulf States. Best development in Western States.	Heavy, hard, strong, more durable than other elms. Used principally for wheel-stock, sills, posts, ties, rails, fuel. Large quantities of the inner bark used for officinal purposes.	Rich, moist, well-drained soil, much like that of the White Elm, but will bear drier and more elevate dsituations. Rapid, but not persistent grower. Easily propagated.

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Preliminary list of the ninety most important timber trees of the United States—Continued.

Name and size.	Distribution.	Quality and uses of wood.	Remarks.
80. **Rock Elm** .... (CORK ELM. HICKORY ELM. WHITE ELM. CLIFF ELM.) (*Ulmus racemosa*, Thomas.) Height, 90 feet +; diameter, 3 feet +.	Northeastern United States ..... Best development in Southern Ontario and Michigan.	Heavy, hard, very strong, tough and *elastic;* superior to that of other elms. Extensively used in the *manufacture* of agricultural implements, wheel-stock, for ties, bridge and building timber, rails, etc.	Rich, moist, heavy, loamy soils. Probably to take the place of the White Elm in forestry.
81. **Yellow Birch** .... (GRAY BIRCH.) (*Betula lutea*, Michx. f.) Height, 80 feet +; diameter, 3 feet +.	Rather Northern .... Best development north of the Great Lakes.	Heavy, very hard, and strong............. Chiefly for furniture, wheel-hubs, pill and match boxes, button and tassel molds, and extensively for *fuel*. Valuable for *cabinet*-wood.	Cool, moist atmosphere preferable. Capable of thriving on poor, but best on a moderately deep, loose, moist sand; hardy and very adaptive to soils; somewhat indifferent to climate. Rapid and tolerably persistent grower; sprouting qualities greatly dependent on site. Light-needing. Easily propagated. For forestry, like all the birches, to be only occasionally and sparingly used as an admixture.
82. **Black Birch** .... (CHERRY BIRCH. SWEET BIRCH. MAHOGANY BIRCH.) (*Betula lenta*, Linn.) Height, 60 feet +; diameter, 3 feet +.	Same range as above...........	Heavy, very strong, hard like that of Yellow Birch, but rose-colored, and perhaps more valuable for cabinet-work. Much used in the manufacture of *furniture* and for fuel.	Same as above species; but apparently not as rapid or as persistent a grower.
83. **Canoe Birch** .... (WHITE BIRCH. PAPER BIRCH.) (*Betula papyrifera*, Marshall.) Height, 60 feet +; diameter, 3 feet +.	Northwestern, Northern, and Northeastern in United States. Reaches a higher latitude than any other American deciduous tree.	Rather heavy, hard, tough, strong; not durable unless protected. Extensively employed in the manufacture of spools, shoe-lasts and pegs, *turnery* of other kinds; lately much used in making *pulp;* excellent *fuel*.	Same as Black Birch, but will probably bear deficient drainage better than other birches.

84. WHITE BIRCH (OLD-FIELD BIRCH. GRAY BIRCH.) (*Betula alba*, var. *populifolia*, Spach.) Height, 25 feet +; diameter, 1 foot +.	Rather Northern	Rather heavy, soft, not strong nor durable. Employed largely for spools, shoe-pegs, *wood-pulp*, hoop-poles, and fuel.	Adapted to drier and poorer soils than other birches. Short-lived; rapid grower; *sprouts readily* from the stump. Probably least important of the birches.
85. Bass Wood (AMERICAN LINDEN. BEE TREE. LIME TREE.) (*Tilia Americana*, Linn.) Height, 100 feet +; diameter, 5 feet +.	East of the Mississippi and Missouri Rivers; wide range. Greatest development in valley of lower Wabash River.	Light, soft, not strong; easily worked. Employed largely in the manufacture of woodenware, cheap furniture, *paper-pulp*, for *panels*, bodies of carriages, clapboards, matched lumber, in turnery, and for light fuel.	Deep, moderately loose, and somewhat moist soil; can endure a wet soil, but will not thrive on a dry one. Rapid and persistent grower; sprouts vigorously from the stump; endures moderate shade. Not very hardy, but in cool situations a desirable adjunct to forestry.
86. SYCAMORE (BUTTON WOOD. BUTTON-BALL TREE. WATER BEECH.) (*Platanus occidentalis*, Linn.) Height, 120 feet +; diameter, 10 feet +.	East of the Mississippi and Missouri Rivers. Best development in bottom-lands of the Ohio and Mississippi Rivers.	Rather heavy, rather hard, not very strong. Extensively used in the manufacture of cigar and tobacco boxes, cheap furniture, for butchers' blocks, ox-yokes, and coarse planks; lately much used for making butter and lard trays and wooden bowls. Little used for fuel, owing to difficulty in splitting.	Rich, moist, soil, low ground, enduring occasional flooding; capable of development on moist upland. Wide climatic range, but liable to frost when young; light-needing; secondary in forestry.
87. COTTONWOOD (CAROLINA POPLAR. BIG COTTONWOOD. NECKLACE POPLAR.) (*Populus monilifera*, Ait.) Height, 100 feet +; diameter, 6 feet +.	East of the Rocky Mountains	Very light, soft, not strong, nor durable when exposed to moisture. Extensively used in manufacture of *paper-pulp*, for lumber, clapboards, matched ceiling, fence-boards, and inferior fuel.	Adapted to a variety of soils, but best in a moist, strong, loamy one. Exceedingly *rapid* grower; sprouts vigorously from the stump; light-needing; *thinning out rapidly*; short-lived and exhaustive to the soil; most readily propagated. Has been recommended for planting on Western prairies, chiefly on account of its rapidity of growth, ease of procuring plant material, and of propagation. In forestry should find a place only thinly interspersed with better and shady kinds.
88. LARGE ASPEN (LARGE-TOOTHED ASPEN.) (*Populus grandidentata*, Michx.) Height 60 feet +; diameter, 2 feet +.	Northern and Northeastern States.	Light, soft, not strong, nor durable when exposed to moisture. Employed chiefly in the manufacture of wood-pulp, and used somewhat in turnery and for woodenware.	The Angular Poplar (*P. angulata*) is said to be superior in quality of timber and of more thrifty growth. Northern States, in moist situations.

Preliminary list of the ninety most important timber trees of the United States—Continued.

Name and size.	Distribution.	Quality and uses of wood.	Remarks.
89. BALM-OF-GILEAD (BALSAM POPLAR. TACAMAHAC.) *Populus balsamifera*, Linn.) Height, 70 feet +; diameter, 5 feet +.	Northern United States	Very light, soft, not strong. Quality of timber quite equal to that of any poplars, but said not to be used where it is abundant. Suitable for woodenware.	A substitute for Cottonwood in the most northern localities.
90. QUAKING ASPEN (AMERICAN ASPEN.) (*Populus tremuloides*, Michx.) Height, 50 feet +; diameter, 1½ feet +.	Northern and Southwestern (in United States); in Pacific region, from 6,000 to 10,000 feet elevation.	Light, soft, not strong nor durable. Employed largely in the manufacture of paper-pulp; in Pacific region used occasionally for flooring, in turnery, and for light fuel.	Of value mainly as a tree naturally covering denuded mountain-sides.

NOTE 1.—Trees which may be looked to as capable of enduring more or less unfavorable sites:
Barren soils: Nos. 3, 4, 24, 30, 40 (?), 47, 55, 58, 62, 84.
Insufficiently drained soils: Nos. 3, 16, 20, 27, 28, 31, 48, 54, 59, 69, 75, 83, 85, 86, 89.
Stiff soils: Nos. 31, 32, 53, 54, 67, 73, 74, 77, 85.
Sea-coast planting: Nos. 3, 24 (?), 30, 32, 84.
Prairie planting—tried: Nos. 1, 30, 51, 58, 60, 62, 63, 66, 67, 68, 70, 74, 77, 78, 79, 87, 89;
worthy of trial: Nos. 2, 10, 24, 39, 40, 71.

NOTE 2.—Of exotics which have been successfully introduced for forest culture, the following may be cited as deserving more or less attention:

Conifers. Scotch Pine (*Pinus sylvestris*, L.), Austrian Pine (*Pinus Austriaca*, Höss.), Corsican Pine (*Pinus Laricio*, Poir.), Norway Spruce (*Picea excelsa*, D C.), Nordmann's Fir (*Abies Nordmanniana*, Link.), European Larch (*Larix Europæa*, D C.).

Broad-leaved Trees: English Oak (*Quercus robur*, L.), Cork Oak (*Quercus Suber*, Linn.), Black Alder (*Alnus glutinosa*, Gaertn.), Ailanthus (*Ailanthus glandulosus*, Desf.), Black Mulberry (*Morus nigra*, L.). Australian Gum Trees: *Eucalyptus globulus*, Labil., *E. rostrata*, Cav. Australian Wattle Trees: *Acacia decurrens*, Willd., *A. pycnantha*, Benth. Gray Poplar (*Populus canescens*, Smith).

Many other trees which occasionally may form desirable adjuncts to the forest might be added to this list, and in the end even the study and propagation of low tree and bush forms for underbrush will require our attention.

To these timbers may be added a number of exotics, especially for planting on the Western plains.

The experiments in this respect need to be very careful as well as methodical, and immediate attention to this branch of forestry should be given. In order to deserve attention for purposes of naturalization, it must be shown of an exotic timber—

(1) That it furnishes better wood than the native species of the same family.

(2) That it will produce in a shorter time larger quantities of wood, even if of less value.

(3) That, even if its wood production be the same or inferior in quantity and quality, it excels the native timber in its frugal demands on the soil, in its value as a nurse, in its resistance to climatic conditions, or in some other particular quality.

In the naturalization of foreign timbers, on account of their qualities in their native habitat, due regard must be paid to the site and soil in which their most favorable development occurs in their native country. Were we, for instance, to place Balsam Fir in a low, warm soil and warm climate, the consequence would be deterioration with advancing years; the mildness of the climate and the rich soil would induce unnatural development, early death, and inferior lumber. Also, if we select a soil which, in regard to its humidity, does not suit the species, while the tree may grow and seemingly thrive, its qualities may be changed and its life shortened.

While hardiness plays so prominent a part in the consideration of exotics for naturalization, it is rational that great stress should be laid upon procuring the seed from most favorable localities, *i. e.*, from the most northern and the driest climates. Carelessness in this respect may often be the cause of failure and disappointment with native as well as with exotic trees. This was the case in Germany during the winter of 1879–'80, when Douglas Spruce grown from California seed was all winter-killed, while the seedlings from Colorado seed were found to be hardy. It should also be insisted upon that the seed comes from vigorous, naturally-grown trees, and it is advisable to have the soil of the nursery similar to that of the forest ground.

The possibility of the naturalization of exotics is not yet as well understood as some people believe. That the degree of moisture in the atmosphere and the range of temperature in its native habitat influence the adaptability of a species to other climes can hardly be doubted. The precaution of getting the seed from the driest and most northern habitat of the species is quite rational, but even with this all the requirements which are necessary for a decision on the hardiness of a tree are not fulfilled. The site and the method of its cultivation have also a great deal to do with the success of its growth. I will cite only one example. The beech is certainly a native of Germany; yet even in the most favorite localities it is almost impossible to raise it in the open without the protection for several years of its parent trees, as it is liable to be killed by late spring frosts. It would, therefore, have to be considered not hardy, or only half hardy, in its native habitat. While some trees may sustain changed climatic conditions for ten or twelve years, and then suddenly succumb unexpectedly to unfavorable climatic conditions, it is a well-observed

fact that other trees, if properly protected in the first years of their existence, become less sensitive to winter cold the older and stronger they grow and the better the last year's shoots have ripened. Thus by placing the tender conifers, like *Cryptomeria*, *Wellingtonia*, *Caryotaxus*, &c., among surrounding quick-growing and densely-foliaged pines, astonishing results may be secured. By placing the firs, most of which are liable to injury by late frosts, in such a manner that the rays of the morning sun in spring do not directly bear upon them, especially on northern or western exposures, these may be propagated in climes in which otherwise they would not be considered hardy. It must not be forgotten that trees which in single individuals fail to answer to our climate may, when planted in forest and grouped with other kinds, very well sustain themselves. Yet, excepting for experiment, it will be well for the present to rely for forest culture mainly on well-proved, hardy plants, and to give the preference to native kinds.

FOREST MANAGEMENT.

While we are, perhaps, still far from the time of systematic forest management in this country, yet the statement of the requirements of such management may not be untimely, as showing how difficult it will be to effect any change in our present methods. The creation of a young forest can be effected either by artificial or natural means; the latter where nature has provided the original forest growth. The methods employed have reference principally to the capacity of trees to reproduce themselves either by shoots from the mother stocks (stumps) or else from seed of the mature trees. The former method is called

COPPICE MANAGEMENT.

It is employed for the production of firewood, tan-bark, charcoal, and wood of small dimensions, and is mostly applicable only to deciduous trees. The capacity of reproduction from the stump is possessed by different species in different degrees, and depends also on climate and soil; shallow soil produces weaker but more numerous shoots than a deep, rich soil, and a mild climate is most favorable to a continuance of the reproductive power. With most trees this capacity decreases after the period of greatest height-growth; they should therefore be cut before the thirtieth year, in order not to exhaust the stocks too much. The oak coppices for tan-bark are managed in a rotation of from ten to twenty years. Regard to the preservation of reproductivity makes it necessary to avoid cutting during heavy frost, to make a smooth cut without severing the bark from the stem, and to make it as low as possible; thus reducing liability to injuries of the stump and inducing the formation of independent roots by the sprouts.

It will be found often that on poor and shallow soil trees will cease to thrive, their tops dying. In such cases it is a wise policy to cut them down, thus getting new, thrifty shoots, for which the larger root system of the old tree can more readily provide. This practice may also be resorted to in order to get a quick, straight growth, as sprouts grow more rapidly than seedlings, the increased proportion of root to the part above ground giving more favorable conditions of food supply. It must not be forgotten, however, that this advantage has to be compensated somewhere else by a disadvantage; sprouts, though growing fast in their youth, cease to grow in height at a comparatively early period, and for the production of long timber such practice would be detrimental.

Regard to the preservation of favorable soil conditions, which suffer by often repeated clearing, requires the planting of new stocks where old ones have failed. Mixed growth, as everywhere, gives the best results. Oaks, walnut, hickory, chestnut, elm, maples, birch, cherry, linden, catalpa, and the locust also, with its root-sprouting habit, can be used for such purpose.

If, when cutting off the sprouts, at the age of from ten to twenty years, some trees are left to grow to larger size, thus combining the coppice with timber forest, a management results which the Germans call "Mittelwald," and which we may call

STANDARD COPPICE.

This is the method of management which, in our country, deserves most attention, especially in the Western prairie States, where the production of fire-wood and timber of small dimensions is of first importance, but the production by the farmer of larger and stronger timbers at the smallest cost should not be neglected. The advantages of this method of management, combining those of the coppice and of the timber forest, are:

(1) A larger yield of wood per acre in a short time.

(2) A better quality of wood.

(3) A production of wood of valuable and various dimensions in the shortest time with hardly any additional cost.

(4) The possibility of giving closer attention to the growth and requirements of single individuals and of each species.

(5) A ready and certain reproduction.

(6) The possibility of collecting or using for reforestation, in addition to the coppice stocks, the seeds of the standards.

If, instead of the pure walnut plantations which have sprung up in the Western States, such plantations had been started on the standard coppice plan, not only would more efficient "self-supporting" forest plantations have been secured, at less cost, but also quicker and better results would have been attained. The under-wood or coppice-wood of inferior kinds could have been cheaply procured, and therefore more densely planted, without much extra cost, thus quickly furnishing the necessary shade to the soil, and in a short time yielding desirable fire-wood, and again sprouting to cover the soil. Then the walnut or other valuable standards would have been permitted to grow on, bearing fruit, and forming, under the influence of enlarged access of light, stouter though shorter timber, of greater value, without losing the needed protection of their foot-cover.

The objections to this mode of treatment are the production of branches on the standards when freed from the surrounding growth, and the fact that the standards act more or less injuriously on the under-wood which they overtop.

The first objection can be overcome to a certain extent by pruning, and the second by proper selection and adjustment of coppice-wood and standards. The selection of standards—which should preferably be seedlings, as coppice-shoots are more liable to deteriorate in later life—must be not only from such species as by isolation will grow into more useful timber, but, if possible, from those which have thin foliage, thus causing the least injury by their cover to the under-wood. The latter should of course be taken from those kinds that will best endure shade. Oaks, ashes, maples, locust, honey-locust, larch, bald cypress, a few birches, and perhaps an occasional aspen, answer well

for the standards; the selection for such should naturally be from the best grown straight trees. The number of standards to be held over for timber depends upon the species and upon the amount of undergrowth which the forester desires to secure. The shadier and the more numerous the standards, the more will the growth of the coppice be suppressed.* From a first plantation one would naturally be inclined to reserve and hold over all the well-grown valuable saplings. The coppice is of course treated as described above.

I have mentioned before that on account of the free enjoyment of light which the standards have they not only develop larger diameters, but also furnish quicker-grown wood (which in deciduous trees is the best) and bear seed earlier, by which the reproduction of the forest from the stump is supplemented and assisted. Any failing plantation of mixed growth, consisting of trees capable of reproduction by coppice, may be recuperated by cutting the larger part back to the stump, and reserving only the most promising trees for standards.

If equally well-grown coppice and standards are desired, a regular distribution of the standards, mostly of the light-needing, thin-foliaged kinds, should be made; if prominence is given to the production of useful sizes, the standards may be held over in groups and irregularly distributed specimens, in which case those of the shade-enduring kinds are best in groups.

The specific application of this method of management for Western practice has been outlined in my report on Western Tree Planting.

THE TIMBER FOREST,

in which it is proposed to grow trees to full maturity for lumber, is reproduced entirely by seed or by planting nursery-grown or forest-grown seedlings. European practice, with its intensive methods of management, necessitated by a crowded population and with its tendency to routine and stereotyped procedure, has developed a form of management which prescribes a clearing of the grown forest and its reproduction by artificial planting, (seeding only where, with less dense population, a small supply of labor or other local peculiarities recommend it); a method which has elicited the admiration of our writers on forestry and our pleasure-seekers abroad, but which must be condemned as being contrary to nature and the best interest of the forest, not being a product of the observance of natural laws, but a child of seeming financial necessity. The simplicity of the method recommends it; but desiccation, deterioration of the forest soil, enormous increase of insect pests on the large sun-warmed clearings which the young planted seedlings are insufficient to protect against the drying influences of sun and wind for a number of years, and other dangers from wind and disease, with the production of less valuable wood (excepting perhaps with conifers), have been the result of these uniform growths. There are but few foresters abroad willing to admit their mistake, most of them clinging to the simple prescriptions of clearing with consequent planting, blinding themselves to the detrimental consequences, or patching them up as best they may. It is

*The cover which trees make at different ages varies of course with species and site, and therefore a general rule cannot be established. From many measurements of deciduous trees in Germany it was found that the average extent of branches of trees 30 years old covered about 40 square feet; of 60 years old, about 126 square feet; of 90 years old, about 262 square feet; of 120 years old, about 448 square feet; and of 150 years old, about 686 square feet; making the number of trees possible with full freedom of crown at the respective ages 1,089, 345, 166, 97, 63 per acre.

perhaps not generally known that unsuccessful forest planting is the not unfrequent complaint of European foresters. The same area must often be replanted or gone over and repaired five, six, nay, ten times. A desire to return to natural methods of reforestation is generally observable with the most practical men, while the scientific pedagogues are still discussing the advantages of their pet method.

The results of this method, which found its advocates and its expansion in the beginning and first half of the century, are naturally only now visible. At that time the forester had in view only the technique of forest planting, and overlooked the fact that he is also called upon to preserve the soil in good condition. We should be wise to learn from this experience, and not be led by the pleasing exterior to follow the same routine, which ultimately must result in a deterioration of the soil of our forest and an increase of its natural enemies.

To be sure, on the treeless plains, and on the cleared and denuded forest areas, we have no choice but to resort to planting; but wherever we are still possessed of natural forests our endeavor should be to reproduce them by natural seeding, supplemented only if necessary by artificial means.

From a financial point of view this method of working for reforestation by the seed from the original timber growth is the only advisable one where soil and timber are cheap and labor difficult to obtain, as is the case in our lumbering regions, and especially so as the lumberman, after having taken what can be converted into cash, is not likely to make any expenditure upon the soil in order to provide for future growth.

The same regard to the principles explained above must be given in the management for natural reproduction as in the planting of new forests; the soil must be kept shaded as continually as possible, and a rational mixture of species must be fostered. In addition, we have to study the requirements of each species in regard to light and shade for their seedlings, and remove the mother trees gradually, slower or faster as required. The idea, still largely urged by popular writers, that a change of crop, a rotation, is as necessary in forestry as in agriculture, must be considered entirely erroneous. The change does often take place through fault of man, not by necessity nor as an advantage, and is easily explained. Light-needing species will take possession of a cleared area which was occupied by a dense-foliaged one, unless the seedlings of the latter were on the ground first, and *vice versa;* thus, if by cutting a thin-foliaged forest (oak) an existing growth of shade-enduring species (white pine) is given the benefit of the increased light, the latter will occupy the ground to the exclusion of the former.

The method of selection, by which only trees of a certain size are cut out, practiced in Canada and to some extent in Maine and in lumber camps elsewhere, would be satisfactory were it carried on with due regard to reforestation, but it is not, for the selection does not take into consideration the requirements of the after-growth, but only the utilization of the selected trees. This method has the advantage at least of exposing the soil less to the drying influence of sun and wind, and of making a natural reforestation from the remaining trees not entirely impossible if the species is a shade-enduring one, and conditions are otherwise favorable; and for this reason its adoption in our pineries (especially those of the white pine, to a considerable extent shade-enduring) would mark a desirable improvement upon the indiscriminate slashing of all growth.

NATURAL REFORESTATION.

The methods of management for natural reforestation from seed in vogue on the European continent can be divided into three classes. Their characteristic is that in utilizing the timber care is taken to consider the requirements of a new growth. The first method is an improvement on the method of selection of our lumbermen. It is the method most suitable to the conditions of the wood lot of the farmer, who can cut as he pleases, can pay attention to details in the removal of the cut timber, and to the requirements of the groups of young growth. This method is the most conservative in regard to the preservation of soil conditions. It is as nearly as possible the forest management of nature, in which trees of different ages and sizes are combined, and for shelter forests is the only advisable plan. It consists in taking out the tall timber, either by single individuals or groups, as necessary, for the benefit of the undergrowth. If old, densely foliaged trees, under which an after-growth is only rarely formed, are thus removed, a large opening is made, and the conditions become favorable for a good new growth from seed of neighboring trees. Under smaller and light-foliaged timber is often found a worthless after-growth. Here a group of the mother trees must be removed, as well as the worthless after-growth, and planting of shade-enduring kinds resorted to.

The possibility of sprouting from the stocks in broad-leaved forests will aid in the reforestation and gradually lead to the adoption of the form described before as standard coppice, the most desirable one for the small forest owner.

For the lumberman and large forest operator this method is objectionable, in so far as it requires the working over too extended an area, making lumbering expensive, besides attention to detail is not as easily given in large areas.

Two methods are applicable to such conditions.

MANAGEMENT IN ECHELONS.

This consists in making the clearing in strips, and awaiting the seeding of the clearing from the neighboring growth. It is applicable to species with light seeds, which the wind can carry over the area to be seeded, such as larches, firs, spruces, most pines, &c.

The cuttings are made as much as possible in an oblong shape, with the longest side at right angles to the direction of the prevailing winds. The breadth of the clearing—on which occasional reserves of not too spreading crowns may be left—depends of course on the distance to which the wind can easily carry the seed which is to cover the cleared area. Observation and experience will determine the distance. In Germany, for spruce and pine, this has been found to be twice the height of the tree; for larch, five or six times the height; for fir, not more than one shaft's length. From 200 to 360 feet is perhaps the range over which seeding may be thus expected. One year rarely suffices to cover the cleared area with young growth, and it takes longer in proportion to the breadth of the cutting. This method is very much less certain in its forestal results than the next named, and more often requires the helping hand of the planter to fill out bare places left uncovered by the natural seeding. But it is the one that seems to interfere least with our present habits of lumbering, and with it eventually the first elements of forestry may be introduced into lumbering operations.

To be sure it requires from three to eight times the area usually brought under operation, but instead of going over the whole area every year it may be operated in a number of small camps systematically placed along a central road connecting the different camps or cuttings with the mill. An ideal arrangement of such management may be sketched thus:

Suppose we have to supply a mill with 2,000,000 feet from pine lands, cutting 8,000 feet an acre, trees which bear seed every two years, and let the period in which full reforestation can be expected be six years. Then a tract of 2,500 acres, or an area of about 3 miles long and $1\frac{1}{4}$ miles broad, must be taken together into operation.

Dividing the tract by a central road on which the mill is situated and making the cuttings 300 feet wide by $1\frac{1}{2}$ miles long, each cutting will contain 54 acres, and about 5 such cuttings will furnish one year's supply, with an average haulage of less than 1 mile to mill—26 cuttings will be located on each side of the road.

The most elaborate method, based and worked on the best scientific principles, for which, however, I am afraid our time has not yet come, is that which we may term the

REGENERATION METHOD.

This method presupposes the growing of timber to maturity, like the former, and depends for the reforestation upon the seed from the mature trees; but it acts upon the consideration of the conditions under which seeds are ripened and germinate, the requirements of the young plants during the first years, especially in regard to light and shade and their further development as a homogeneous crop. This method has been carefully elaborated, with much detail, for the different species forming European forests. But as its application in the near future in our forests cannot be expected, it may suffice to give the rationale underlying it. In the first place, it is necessary to know the period at which a full seed year can be expected. This differs according to locality and kind.* One or more years before such a seed year is expected the hitherto dense crown cover is broken by a preparatory cutting, enough of the inferior timber being taken out to let in some light, or rather warm sunshine, which favors a fuller development of seed, the increased circulation of air and light at the same time hastening the decomposition of the leaf-mold and thus forming an acceptable seed-bed.

As soon as the seed has dropped to the soil, and perhaps, in the case of acorns and nuts, been covered by allowing pigs to run where it has fallen, a second cutting takes place uniformly over the area to be regenerated, in order that the seeds may have the best chance for germination—air, moisture, and heat to some degree being necessary—and that the seedlings may have a proper enjoyment of light for their best development and yet not be exposed too much to the hot rays of the sun, which by producing too rapid evaporation and drying up the needful soil moisture would endanger the tender seedlings. This cutting requires the nicest adjustment, according to the state of the

*In Germany such seed years occur in beech, according to locality, every three to twenty years, and account is kept of them. In Northern New York the beech seems to bear full seed every two years; like periodicity of seeding in the white pine (probably triennial for most localities) and in the long-leaf pine (probably five to seven years) has been observed.

soil, climatic conditions, and the requirements of seedlings of different kinds. While the beech requires the darkest shade, the pine tribe and the oaks are more eager for light, and should by the successive cuttings be early freed from the shade of the mother trees. Beech seedlings are more tender, and only by the gradual removal (often protracted through many years) of the shelter of the parent trees can be accustomed to shift for themselves, without liability of being killed by frost. The final cutting of the former generation of trees leaves many thousand little seedlings closely covering the soil with a dense shade.

That the method of management must differ according to species and local conditions is evident; and especially in a mixed forest is the best skill and judgment of the forester required to insure favorable conditions for each kind that is to be reproduced. That such seedings are rarely satisfactory over the whole area, and that bare places of too large extent must be artificially sown or planted. is to be expected.

CLEANING AND THINNING.

There are in such a natural growth, of course, more individuals to the acre than can be expected to develop. A struggle for existence soon begins, and a constant natural thinning out is the result, requiring the judicious aid of the forester to produce a desirable termination of the struggle. In this the one point never to be lost sight of is, to keep the soil well shaded. In fact, with this one general rule in view any practical man may be expected to make few mistakes in the removal of trees when the necessity for it appears, which does not occur until the stems have reached the size of hop poles. Before that time the clearings are mainly to afford protection to the slower-growing and more valuable species by removing or cutting back the quicker-growing and inferior kinds. By no means, however, should the small shrub vegetation ever be disturbed, unless spreading over valuable timber-growth. So far from injuring the future trees of the forest this undergrowth is a decided benefit, keeping the soil shaded and sheltered against winds, and therefore moist, and adding to its riches by the decay of its leaf-mold. On the other hand, if of two or more valuable kinds one threatens to overtop the other and to shade it out, the ax may properly do its work in preserving the deserving weaker one. The question whether a more vigorous clearing out in the earlier stages of development does not favor better development of the remaining growth without injury to soil conditions is still an open one, though experiments for its decision have been instituted.

Up to a certain point the effect of the struggle between the trees of an even-grown thicket must be considered distinctly useful by forcing height growth and showing more clearly which are the individuals of weak constitution and therefore not destined to become the dominant growth of the forest. Among this class, which we may call the over-shaded, moves mainly the work of interlucation, *i. e.*, the periodical thinnings which are made for the purpose of stimulating increased development in the dominant, fore-grown trees, and which is due to the increased enjoyment of light and room.

How this struggle for life and supremacy, by exclusion of the neighbor from the necessary factor of existence, light, proceeds in a naturally grown forest is shown in the following interesting table, which

was obtained by counting the trees of a naturally-grown, dense Norway spruce forest at different ages.

Age.	Trees per acre.	Overgrown.	Dominant growth.	Standing room per tree.
	Number.	*Per cent.*	*Number.*	*Square ft.*
20 years	9,377	49	4,783	4.64
40 years	1,235	42	733	34.43
60 years	604	32	410	72.11
80 years	393	21	310	110.70
100 years	285	11	253	156.00
120 years	241	4	231	180.75

Such a table is most instructive in many ways. If, for instance, as appears, only 733 trees per acre can reach a satisfactory development in 40 years, why plant more of a costly, valuable kind? Why not limit ourselves to that number at first, and for the purpose of shading the ground and stimulating growth fill up the space between them with a cheaper material?

It shows that the struggle for dominance is severest in the period from the twentieth to the fortieth year, gradually decreasing with advancing age. From this we may infer that interlucations are most effective in the earlier period. It shows us that those trees which are now dominant, seemingly in full vigor, may yet be overshaded and at last subdued by their neighbors. Thus we may group the trees of the naturally grown forest into the following classes:

1. The fore-grown or dominant; which might be subdivided into (*a*) predominant, (*b*) codominant, (*c*) followers.
2. The overshaded; subdivided into (*d*) overwhelmed and (*e*) subdued.

By interlucations we imitate, assist, anticipate nature in this process of elimination, and according to the degree of our thinning we speak of a dark interlucation, which removes only the subdued, dead, and dying stems; a moderate one, which takes all the overgrown, and a severe one, which attacks also the lowest grades of the fore-grown, and even interrupts somewhat the upper crown cover. The degree of interlucation to be practiced depends greatly on the soil and the exposure; a dark interlucation is in most cases sufficient.

The necessity of a stronger interlucation presents itself in a growth with an unusually large number of stems of uniform caliber, where sometimes the struggle for supremacy is unduly prolonged and the lessening of overstock is needed to secure the development of larger dimensions. Predominant stems ought to be taken only exceptionally, when a more valuable kind, which we want to favor—as, for instance, white oak—is in danger of being overwhelmed by a less valuable overgrowing neighbor; or when, on account of some peculiarities of an accidentally foregrown species of tree, detrimental consequences must be anticipated, as, for instance, when the birch (which only too easily finds entrance into our plantations), with its whipping branches, may injure and strip the young buds of the pine or fir.

A deep, rich soil, with abundant moisture, on northern and northwestern exposures, will endure a strong interlucation with least injury, because the vigorous growth due to its favorable conditions will soonest close any gaps. On the other hand, it will almost always be well to leave even subdued stems on thin and dry soils and those exposed places where by their removal entrance would be given to drying winds and sun.

The degree of thinning depends also a great deal on the species forming the forest. In another place I have pointed out the importance of the classification of the different species with reference to their relation to light and shade, as shade-enduring and light-needing. This classification has some bearing on the degree of interlucation. Those kinds which for their development require a larger amount of light would naturally show in a dense growth a greater amount of subdued stems, and consequently a stronger interlucation would be indicated. On the other hand, these very species are the ones which are least capable of preserving favorable soil conditions, because their naturally thin foliage not only does little toward the increase of the layer of humus, but does not efficiently exclude the rays of the sun, especially as they have the tendency with increasing age to thin out still more their leafage. They are, therefore, the most difficult to manage, and the continuity of their crowns must be most carefully preserved.

The time when the first thinning should take place is generally determined by the possibility of marketing the extracted material at a price which will cover at least the expense of the operation. This is, however, not always possible, and the consideration of the increase in value of the remaining growth, or rather of the detriment to the same by omission of timely thinning, may then be conclusive.

On good soil and on mild exposures interlucation may take place earliest, because here the growth is rankest and a difference in the development of the different stems is soonest noticeable. Light-needing and quicker-growing kinds show similar conditions to those grown on good soil, and here, therefore, early thinnings are desirable. In these cases the thinnings have also to be repeated oftenest, especially during the period of prevalent height accretion. Absolute rules as to the time for interlucations and their periodical repetition evidently cannot be given; the peculiar conditions of each individual case alone can determine this. The golden rule, however, is: early, often, moderately. The right time for the beginning of these regular and periodical interlucations is generally considered to have arrived when the natural thinning out mentioned before commences and shows the need of the operation. This occurs generally when the crop has attained the size of hop poles. At this stage the well-marked difference in size of the suppressed trees will point them out as having to fall, and there will not be much risk of making any gross mistakes. Until the trees have attained their full height the thinning should remain moderate. From this time forward it will prove expedient to open out the stock more freely, without ever going so far as to thin severely.

OTHER METHODS OF MANAGEMENT.

The methods of management briefly outlined above are the principal ones and serve as the basis of all others, which are mostly modifications of these. Methods are also practised by which a combination of agricultural use of the soil with forestry takes place. While in these there is much that seems attractive, they can be considered only in the same light as combination tools, which are generally defective at one end or both—the poor man's tool—a poverty-stricken practice, to which our rich and broad lands need not yet be subjected. Unless it were to reduce the cost of cultivation in young plantations on agricultural soil by the introduction during the first two years of a crop of potatoes or other cultivated crop, a practice which may be

even recommended, the combination of agriculture with forestry for obvious reason can be considered only detrimental to both.

CONCLUSION.

As in medicine the charlatan will prescribe without diagnosis, so in forestry he must be called a charlatan who would attempt to give rules applicable to all conditions and under all circumstances. A diagnosis not only of the local conditions as to soil, climate, flora, &c., but also of the objects and the financial capacity of the would-be forester, must precede special advice. In this report, therefore, the attempt has been made only to outline the first principles, from which a thinking reader may find the application to his special case.

OSIER WILLOW CULTURE.

Many inquiries have come to the Department in regard to methods of Osier planting; showing that this branch of forestry, applicable to many soils, seemingly simple and promising quick returns, has attracted widespread attention. The Division has, therefore, begun to prepare a manual on willow culture, as a preliminary of which the following brief instructions are here given, compiled from reliable authorities.

It should be premised that osier growing for profit is not so simple and easy or inexpensive an enterprise as might at first appear. The market for the material is the first point to be considered, and in connection with it the kinds that will grow successfully and profitably. So far it seems that the climate of the United States, in most parts, with its long, hot summers, is not very favorable to the growth of the finer grades of osier rods, at least not of the European kinds, which, with one exception, are pronounced unsuitable, while American willows are not yet sufficiently tested to warrant their extensive employment for osier holts.

The importation of osier rods, formerly under a duty of 30, now of 25 per cent. ad valorem, amounts annually to over $50,000 in value, while that of manufactured basket and osier ware, under a duty of, formerly 35, now 30 per cent., during the last five years has averaged $243,185. To obtain the material thus imported, which cannot be less than 10,000 tons, we might well devote 6,000 to 10,000 acres of agriculturally worthless soil, if we can so secure a desirable product.

Selection of soil.—To make osier holts profitable such soils should be selected as cannot otherwise be used to advantage. Very poor soils, however, should be avoided, unless there is a good market for inferior material. The best soil is a fresh, black sand, but even a heavy, compact loam, and rich but sour meadow land, which produces the poorest quality of grass, is always equally acceptable.

Peaty soil, if it can be covered with a layer of sand or loam (from the drain ditches), will produce a good growth. The Caspican willow will thrive on poorest sand. Planted on the embankments of brooks, ponds, ditches, the osier will secure the embankment and yield a good profit besides. Never plant on soil liable to be covered with stagnant water in summer. By making drains in such localities, however, good crops can be procured. Localities liable to late spring frosts should be avoided.

Cultivation of soil.—Plow or spade the ground 16 to 20 inches deep; deeper if the subsoil brought up would improve the ground (sand or loam below peat); less deeply if the soil is shallow and the subsoil meager. Spading offers opportunity of burying the weedy surface more effectively. Wet ground should be formed into raised beds of from 30 to 50 feet wide, leaving 2-foot ditches, by which the water is quickly drained off.

The water-level should be laid at least one and a half feet deep. In spading care

should be taken to bring the surface soil under and the subsoil on top. By this means the roots will be benefited by the vegetable mold of the surface soil and the subsoil at the surface will prevent a rapid running to weeds. For spring planting the soil must be prepared in fall or early winter, so that it may be pulverized by the frosts.

Choice of varieties.—Out of upwards of 250 species of willow, and their endless number of varieties and bastards, only a limited number have been found of economic value, especially for osier purposes. While for European climates the best varieties have, by careful experiment and long experience, been established, we cannot yet speak authoritatively for this country, especially about the capabilities of our native willows.

Such an authority as Dr. C. L. Anderson, of Santa Cruz, Cal., states in a letter to the Department, "Our native California willows, especially those growing here at Santa Cruz and vicinity, answer very well for all purposes. Baskets, hoops, &c., are made from all varieties that have the habit of growing along our streams. There is a difference, however.

"*Salix lævigata*, Bebb., (no common name), *Salix lasiandra*, Benth. (no common name) and its varieties, and *Salix lasiolepis*, var. *Bigelovii*, Bebb, (no common name), seem to be preferable. On wet prairies from Illinois and Wisconsin northwestward is found plentifully a variety (*gracilis*) of this species, the twigs of which are collected near Chicago by Germans and sold to dealers in that city.

"*Salix cordata* (var. *vestita*, Anderson—Diamond willow) common clear across the continent, twigs stout, suitable for the heaviest kinds of basket work; bronze or yellowish green, often bright red when exposed to much sunlight; not so tough and pliant as those of *S. sericea* and *petiolaris*.

These all grow rapidly, are hardy, and the texture is sufficiently tough. There is a variety of *Salix lasiandra* that has not been sufficiently described. The branches are long, slender, and drooping, and have the appearance of the weeping willow. This variety is exceedingly well adapted to economic uses."

Prof. M. S. Bebb, of Rockford, Ill., the American authority on willows, in a lengthy letter on the subject of economically useful varieties, after reciting his failures with European species and varieties, says: "My strong conviction is that success in osier growing throughout the corn belt east of the Rocky Mountains will only be attained by making good use of plants adapted to the climatic conditions, and even then that the product will fall below the best European in quality. * * * *Salix purpurea*, in some of its forms most highly esteemed abroad for osiers, is checked also by the midsummer conditions, but not to so great an extent as the sorts above mentioned, and one form which you particularize, viz, *Salix purpurea pyramidalis*, I should regard as a hopeful subject. * * * Of willows indigenous east of the Mississippi River, I would name the following as perhaps the most promising kinds for future trial:

"*Salix sericea* (common eastward), a bushy shrub 6 to 10 feet high; branches reddish green or greenish, at length olive; twigs long, slender, and very tough, yet extremely brittle for an inch or two at base.

"*Salix petiolaris* (common westward), near akin to the former, habit quite similar; twigs usually yellow or tinged with crimson; not so brittle at base."

From correspondence so far had with practical osier-growers in the East, the species most successfully grown in the Northeastern States, and seemingly, too, in Georgia, is the *Salix purpurea*, commonly called the red osier; but which of the several varieties this is has not yet been established—probably *pyramidalis*. The red osiers are of German origin, and are considered the most useful, making numerous pliant, thin, slender, evenly-grown rods, without branches; especially adapted for binding and wattling purposes; growing well on a moist, but also drier, sand soil, less so on compact soils, but again excellently on mucky soils. They are least affected by heat and cold, wet and dry. But compared with other kinds grown in Europe their yields are somewhat inferior, giving a full crop only after the third or fourth year.

Altogether vigorous growers are to be most recommended, yet even on the best soils, with quick-growing kinds, the growth diminishes after a few years.

In the selection of species it is not to be forgotten that while they must be adapted to climate and soil and be good and persistent producers, the kind of material furnished by them is to be kept in view, as different species and varieties differ in this respect.

Planting of cuttings.—The best time for planting is the late fall, generally the end of October. For such planting the soil should be prepared in spring or early summer and left fallow. If the spading has been done in the fall or winter, the planting should be delayed till early spring. The growth of the cuttings is the more assured the less advanced the spring growth. To retard early growth, take the cuttings before the 1st of March and lay them in water. Take cuttings only from main shoots, and only

from the lower half of these, because the tops would yield too weak material. The best length for cuttings is about 12 inches; on compact moist soils a length of 10 inches will suffice, while on dry sand and peat soils 14 to 16 inches may be taken, in order to get the larger number of roots in the first season, the number of roots being to some extent dependent on the length of the cutting under ground. Place cuttings in the ground so that the tops are even with the surface, but on compact and caking soil, which would hinder the buds from pushing through, leave two or three buds above ground. After the shoot is started it is well to draw the earth up to cover the entire cutting, as many dangers beset the top when left free—injuries in cutting, from drying, and from insects. Take care to pack the soil closely around the whole length of the cutting. The practice of placing the cuttings inclined is without rational foundation. Cuttings for planting are best taken during winter, when vegetation rests, and may be taken from three, two, or even one year old wood, if of good size. The distance at which osiers are planted varies. Two considerations must be kept in view, the possibility of cultivating and working between the rows, and the desirability of shading the ground as closely as possible, which keeps the soil moist and free from weeds and, to some extent, from insects. A distance of 20 inches for the rows and of 4 inches in the row answers these purposes.

Cultivation.—In the first year this is best delayed until the middle of June, to avoid disturbing the small rootlets. When cultivating, first mainly subdue the weeds and hill up the soil around the cuttings. Second and third weedings should be in August and September. Before winter sets in the plantation should be free from weeds. In the second and third year thorough cultivation is required. The first cultivation should now be given as soon as the frost is out of the ground. All cultivation must be shallow, not more than 2 inches deep, so as not to injure the roots.

Manuring.—There is no doubt that by the use of manure or compost the yield can be largely increased, but it is mostly too expensive, as the material would have to be carried into the plantation by hand. As to fertilizers, mucky and peaty soils should not receive an increase of nitrogenous matter, though this is desirable, however, on poor sands and meager loams. Phosphoric acid fertilizers improve the quality of the osiers; the cheap phosphorites, which are readily assimilated, are particularly desirable. Potash, forming a large part of the constituents of willows, is especially effective. Fertilizers are best applied during rainy weather and early in the season, as soon as the rods have been cut.

Insects.—The experience that extensive plantations of one kind increase the number of their enemies holds good for osier holts. Most of the injurious insects are beetles and their larvæ. The former let themselves drop to the ground from their host as soon as this is touched. This habit allows the use of apparatus to catch the beetles in quantity, which should be done as early in spring as possible.

The application of quick-lime, of hellebore, and of Paris green has been found successful by Mr. L. Gleason, an extensive osier-grower in Syracuse, N. Y.

The red osier, (*Salix purpurea*), is especially liable to the attack of a gall-wasp (*Cecidomyia salicis*), but its spread can be avoided by cutting and burning up all infected rods.

Harvest.—Osiers should be cut the first year, even if no valuable material can be got. If the cutting is delayed until the second year, branching takes place, and less valuable material is obtained. They should also be cut in the second and third years, but should be left uncut the fourth year to grow to hoop-poles in two to four years. If there be no sufficient market for hoop-poles the yearly cutting may be continued until the growth becomes too slim, which is generally in ten to fifteen years. Cutting of rods should be done during winter, from November 1 to March 1; cut as near the ground as possible. Keep the rods in running water, standing upright, 4 inches of the butts under water, until they peel easily.

Hand-peeled stock is preferred and brings a higher price than steam-peeled rods; the price last year was from 6 to 8 cents per pound. In an average of five years the yield may be from 90 to 130 pounds per 100 stocks. Mr. I. C. Plant, of Macon, Ga., reports one and one-half tons from a three-years' plantation, planted 15 inches in the rows and 5 feet apart.

In this report credit is due in the figuring of statistical tables to Mr. N. H. Egleston, and in the compilation of notes for the list of timber trees to Mr. George B. Sudworth, of the Division.

B. E. FERNOW,
Chief of the Forestry Division.

Hon. NORMAN J. COLMAN,
Commissioner.

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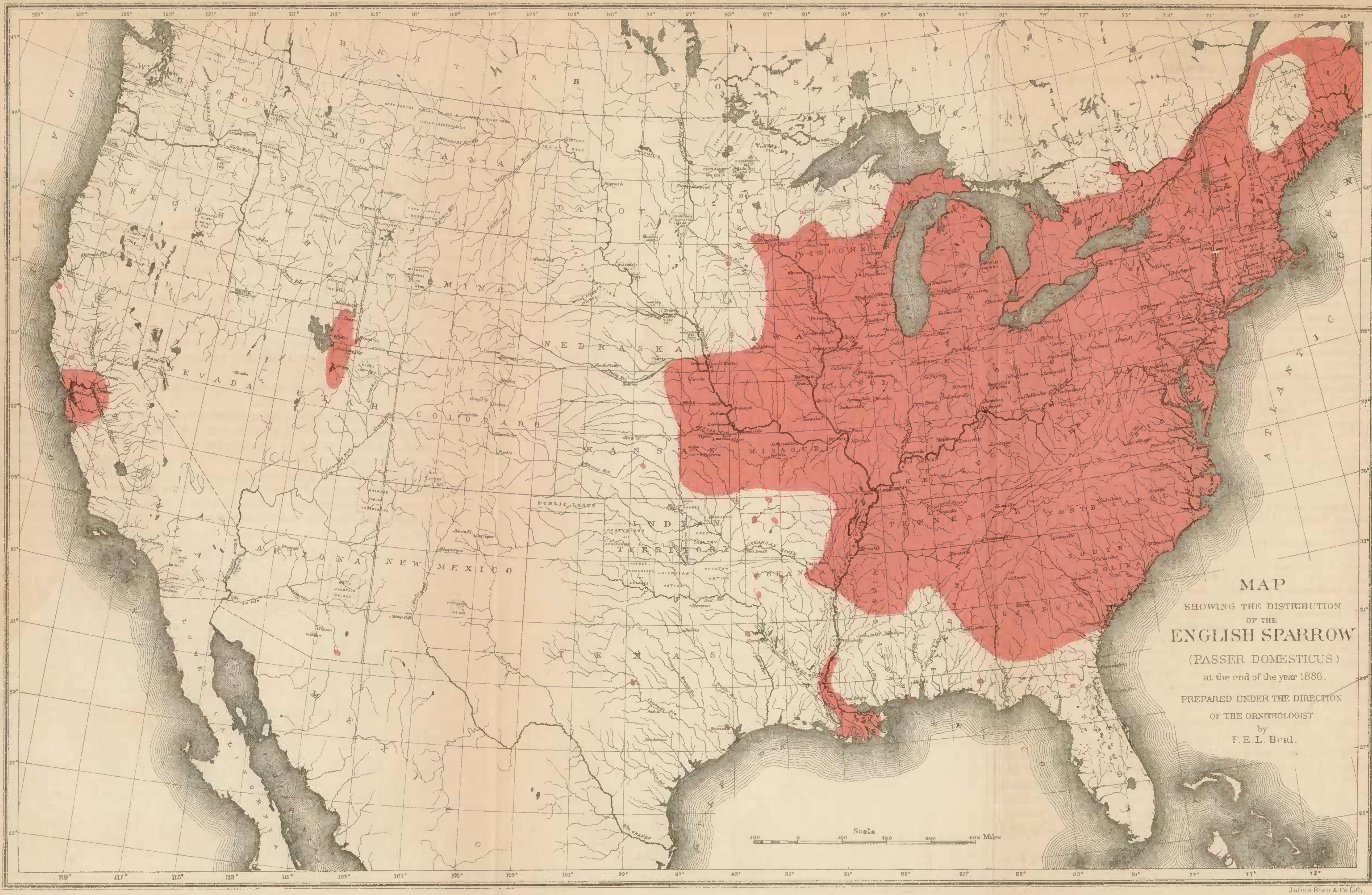

MAP
SHOWING THE DISTRIBUTION
OF THE
ENGLISH SPARROW
(PASSER DOMESTICUS)
at the end of the year 1886.
PREPARED UNDER THE DIRECTION
OF THE ORNITHOLOGIST
by
F. E. L. Beal.
Scale
400 Miles
Julius Bien & Co. Lith.

REPORT OF ORNITHOLOGIST AND MAMMALOGIST.

SIR: I have the honor to submit the following report of the investigations of the Department in Economic Ornithology from the commencement of the work, July 1, 1885, to the present time.

As you are aware, the Forty-eighth Congress appropriated $5,000 for the promotion of economic ornithology, and made the work a branch of the Division of Entomology. The appropriation became available July 1, 1885, at which time you commissioned me to take charge of the investigations.

A year later, July 1, 1886, pursuant to an act of the Forty-ninth Congress, the work was separated from the Division of Entomology and made an independent division. At the same time its scope was enlarged and its usefulness greatly increased, since the appropriation of $10,000 had been granted "for the promotion of economic ornithology and mammalogy; an investigation of the food-habits, distribution, and migrations of North American birds and mammals in relation to agriculture, horticulture, and forestry."

The work of the division consists in the collection of facts relating to the above subjects, and in the preparation for distribution among farmers and others of special reports and bulletins upon birds and mammals which affect the interests of the farmer, and also upon the migration and distribution of North American species. In this way it is hoped to correct the present widespread ignorance concerning the injurious and beneficial effects of our common birds and mammals, and to put a stop to the wholesale destruction of useful species now going on.

IMPORTANCE OF THE SUBJECT.

The food of all species consists either of animal matter or vegetable matter or both, and its consumption must be serviceable or prejudicial to the interests of mankind. Therefore, according to the food it eats, each bird or mammal may be classed under one of two headings—beneficial or injurious. Many species are both beneficial and injurious, and it is impossible to assign them to either category until the percentages of their food-elements have been positively determined and the sum of the good balanced against the sum of the evil.

It is well known that certain birds and mammals are directly destructive to farm crops, causing a loss of many thousands of dollars each year, and that others are highly beneficial, preying upon mice and insects which are injurious to vegetation; but the extent and significance of these effects and their bearing on practical agriculture is little understood. Morever, great difference of opinion exists, particularly among farmers, as to whether certain well-known species are on the whole beneficial or injurious; and many kinds which are of great practical value are killed whenever opportunity offers. For example, hawks and owls are almost universally regarded as detrimental, while as a matter of fact most of them never touch poultry,

but feed largely, and some almost exclusively, on mice and grasshoppers. Skunks and weasels sometimes prey upon poultry, and for this reason are condemned and destroyed. But, in reality, fully 90 per cent. of their food consists of mice and insects, and their occasional depredations in the poultry yard are unworthy of mention in view of their constant and unremitting services. In fact, I do not hesitate to assert that a single skunk or weasel nets the farmer more in dollars and cents each year than he loses from their depredations during his entire lifetime. And yet so short-sighted is he that he rarely lets slip a chance to kill them; and were these animals more diurnal in habits their race doubtless would be ere now well-nigh exterminated. It may be added that much of the mischief commonly attributed to the weasel and skunk is the work of the mink—the greatest enemy to poultry-farming in this country. It should be mentioned in this connection that the habit of killing poultry is by no means general among the animals that practise it. On the contrary, it is limited to comparatively few individuals, precisely as in the case of the domestic cat and dog. But when once the habit has been formed it is not likely to be abandoned; hence the guilty animal should be killed as soon as possible after the habit is discovered.

THE PENNSYLVANIA "SCALP ACT" OF 1885.

On the 23d of June, 1885, the legislature of Pennsylvania passed an act known as the "scalp act," ostensibly "for the benefit of agriculture," which provides a bounty of 50 cents each on Hawks, Owls, Weasels, and Minks killed within the limits of the State, and a fee of 20 cents to the notary or justice taking the affidavit.

By virtue of this act about $90,000 has been paid in bounties during the year and a half that has elapsed since the law went into effect. This represents the destruction of at least 128,571 of the above-mentioned animals, most of which were Hawks and Owls.

Granting that five thousand chickens are killed annually in Pennsylvania by Hawks and Owls, and that they are worth 25 cents each (a liberal estimate in view of the fact that a large proportion of them are killed when very young), the total loss would be $1,250, and the poultry killed in a year and a half would be worth $1,875. Hence it appears that during the past eighteen months the State of Pennsylvania has expended $90,000 to save its farmers a loss of $1,875. But this estimate by no means represents the actual loss to the farmer and tax-payer of the State. It is within bounds to say that in the course of a year every Hawk and Owl destroys at least one thousand mice, or their equivalent in insects, and that each mouse or its equivalent so destroyed would cause the farmer a loss of 2 cents per annum. Therefore, omitting all reference to the enormous increase in the numbers of these noxious animals when nature's means of holding them in check has been removed, the lowest possible estimate of the value to the farmer of each Hawk, Owl, and Weasel would be $20 a year, or $30 in a year and a half.

Hence, in addition to the $90,000 actually expended by the State in destroying 128,571 of its benefactors, it has incurred a loss to its agricultural interests of at least $3,857,130, or a total loss of $3,947,130 in a year and a half, which is at the rate of $2,631,420 per annum! In other words, the State has thrown away $2,105 for every dollar saved! And even this does not represent fairly the full loss, for the slaughter of such a vast number of predaceous birds and mammals is

almost certain to be followed by a correspondingly enormous increase in the numbers of mice and insects formerly held in check by them, and it will take many years to restore the balance thus blindly destroyed through ignorance of the economic relations of our common birds and mammals.

A knowledge of the food-habits of our common birds and mammals would benefit every intelligent farmer to the extent of many dollars each year, and occasionally would save him the loss of an entire crop. It would save certain States many thousands of dollars which they now throw away in bounties, and would add millions of dollars to the proceeds derived from our agricultural industries.

Hence it becomes the duty of the division to attempt to educate the farming classes in the truths of economic ornithology and mammalogy.

Among the many subjects now demanding the attention of the division are: The depredations of Ricebirds in the South; the status of the so-called English Sparrow in America; the true status of the various birds of prey in relation to agriculture; the depredations of Blackbirds in the grain-growing districts of the Northwest; the destruction of small fruits by birds; the depredations of small mammals, particularly in the West; and the true status of the several species of mammals which prey upon poultry.

PROGRESS OF THE WORK.

Early in July, 1885, a circular was prepared, explaining the objects of the inquiry and asking for information in reply to a number of questions concerning the food-habits of several of our well-known birds. At the same time a collection of the crops, gizzards, and stomachs of birds was begun, for it was clear that in a comprehensive investigation of this kind the study of a bird's habits in the field must be supplemented by a critical examination of its stomach-contents in the laboratory. In this undertaking the Department has been aided by ornithologists throughout the country, many of whom have made large and valuable contributions, thus doubly utilizing birds killed for strictly scientific purposes.

In collecting the facts necessary to a clear conception of the practical side of the question a very large amount of information of great scientific value is incidentally brought together. The migration observers of the American Ornithologists' Union have accumulated a vast quantity of original material, the use of which has been freely accorded the division of economic ornithology. Moreover, a large proportion of the same observers continue to collect data and make reports, which, through the courtesy of the Union, are now sent direct to the Department. But the study of migration and distribution has been subordinated to the study of the more practical phases of the inquiry, for it is the bearing of these investigations upon the avocations of the farmer and fruit-grower that chiefly concerns the Department of Agriculture.

Therefore, in order to obtain a large array of facts, and in some cases the opinions of persons interested as well, I prepared the following circulars, which, with the exception of the one addressed to rice-growers, were sent to the secretaries of the various agricultural and horticultural societies throughout the country, to the agricultural press, and to a large number of farmers and ornithologists. The circular to rice-growers was sent to the addresses of as many rice-plant-

ers as the Department was able to secure, and to the editors of newspapers published in the rice-growing districts.

Following are copies of the circulars issued by the Division of Economic Ornithology and Mammalogy in July, 1886:

[Circular No. 1.]

CIRCULAR ON THE FOOD-HABITS OF BIRDS.

It is well known that certain birds are directly destructive to farm crops, causing a loss of many thousands of dollars each year, and that others are highly beneficial, preying upon mice and insects which are injurious to vegetation; but the extent and significance of these effects, and their bearing on practical agriculture, is little understood. Moreover, great difference of opinion exists, particularly among farmers, as to whether certain well-known species are, on the whole, beneficial or injurious; and many kinds which are really of great practical value are killed whenever opportunity offers. For example, hawks and owls are almost universally regarded as detrimental, while as a matter of fact most of them never touch poultry, but feed largely, and some almost exclusively, on mice and grasshoppers.

The wholesale slaughter of small birds has been known to be followed by serious increase of noxious insects; and invasions of insects which threatened to devastate large tracts of country have been cut nearly short by the timely services of some of our native birds.

In view of the above facts, and many others which might be cited, it is clear that a comprehensive, systematic investigation of the interrelation of birds and agriculture will prove of enormous value to farmers and horticulturists. Such an investigation has been undertaken by the newly established Division of Economic Ornithology of the Department of Agriculture, and the assistance and co-operation of persons interested are earnestly solicited.

The food of all birds consists either of animal matter or vegetable matter, or both, and its consumption must be serviceable or prejudicial to the interests of mankind. Therefore, according to the food they eat, all birds may be classed under one of two headings—beneficial or injurious. Many species are both beneficial and injurious, and it is impossible to assign them to either category until the percentages of their food-elements have been positively determined and the sum of the good balanced against the sum of the evil.

In a very large proportion of our small birds the food varies considerably with the season, sometimes changing from vegetable to animal, or from injurious to beneficial. Furthermore, many birds feed their young upon substances which the adults rarely or never eat; and the young on leaving the nest sometimes greedily devour things which are discarded as they grow older. Hence it becomes necessary to ascertain the food of each species at different times of the year and at different ages.

Information is desired on all questions relating to this inquiry, and special attention is invited to the following:

1. Has the common Crow been observed to catch young chickens or to steal eggs?

2. Has it been observed to eat corn or other cereals in the field? If so, how long after planting, and how extensive was the injury done?

3. Has the Crow been observed to feed upon injurious insects? If so, what kinds of insects were thus destroyed, and to what extent?

4. Has the Crow-Blackbird or Grakle been observed to carry off the young of the Robin or of other small birds, or to destroy their eggs?

5. When breeding near the house, has it been observed to drive off small birds, such as Robins, Bluebirds, &c., which had previously made their abode on the premises?

6. Has it been observed to eat corn or other cereals in the field? If so, how long after planting, and how extensive was the injury done?

7. Has the Crow-Blackbird been observed to feed upon injurious insects? If so, what kinds of insects were thus destroyed, and to what extent?

8. What birds have been observed to feed upon or otherwise injure buds or foliage, and what plants or trees have been so injured?

9. What birds have been observed to feed extensively upon fruit? What kind or kinds of fruit have been most injured by each species, and how extensive have been the losses thus occasioned?

10. The Bobolink (Rice-bird or May-bird of the Southern States) congregates in vast flocks during its migrations and commits extensive depredations in certain parts of the South. The division will be glad to receive detailed accounts of these

depredations from persons living in the affected districts, to whom a special circular will be sent on application.

11. What birds are considered to be injurious to grain crops, and what kinds are regarded as beneficial? On what facts are these opinions based?

12. What birds have been observed to feed upon injurious insects, and upon what kind or kinds does each bird feed?

13. Do Blackbirds (other than the Crow-blackbird already mentioned) commit serious depredations in your vicinity? If so, which of the several species of Blackbirds are concerned, and what crops are affected?

14. Has any kind of bird been observed to feed upon the honey-bee? If so, what species, and how extensive has been the injury done?

When possible, the exact date should be given of all occurrences reported.

Persons willing to aid in the collection of birds' stomachs will be furnished with the necessary blanks and instructions.

Special circulars on the English Sparrow and on the economic relations of mammals will be furnished on application.

[Circular No. 2.]

CIRCULAR ON THE ENGLISH SPARROW.

(*Passer domesticus.*)

The Department of Agriculture desires facts, from personal observation, in answer to the following questions concerning the European House Sparrow, commonly called "English Sparrow" in this country.

I. Is your locality city, suburb, or country?

II. Is the English Sparrow present in your vicinity? If not, what is the nearest point at which you know it to occur? If present, when did it first appear?

III. Is it abundant and on the increase?

IV. Is it protected by law?

V. Is it artificially housed and fed?

VI. How many broods and young does a single pair rear in a season?

VII. Do any of our non-predatory birds habitually resist encroachments of, or attempt to drive off, the English Sparrow unless themselves first attacked, and with what success?

VIII. Which of our native birds attempt to reclaim former nesting sites when these are occupied by the Sparrows? State examples.

IX. Has the English Sparrow been observed to molest or drive off any of our native birds? If so, what species are so molested or expelled from their former haunts?

X. Does it injure shade, fruit, or ornamental trees or vines?

XI. Does it injure garden fruits and vegetables?

XII. Does it injure grain crops?

XIII. Has any case in which it has been of marked benefit to the farmer or horticulturist come under your notice? If so, in what way has the benefit been derived?

XIV. Under what circumstances does it feed upon insects? What kinds of injurious or beneficial insects or their larvæ does it destroy, and to what extent?

XV. What means, if any, have been taken to restrict the increase of the English Sparrow?

XVI. What is the prevailing public sentiment in respect to the bird?

Information is particularly desired concerning the presence of the English Sparrow in the Southern States and in the region west of the Mississippi.

[Circular No. 3.]

CIRCULAR ON THE ECONOMIC RELATIONS OF MAMMALS.

The Department of Agriculture desires information concerning the effects of mammals upon agriculture, and solicits replies to the following questions:

To stock-raisers on the frontier.

1. Have you personal knowledge of one or more cases in which cattle, horses, sheep, or pigs have been killed or injured by Bears, Wolves, or Panthers (known in the West as Mountain Lions)? If so, give full particulars.

To poultry fanciers.

2. Have you personal knowledge of the loss of turkeys, geese, ducks, chickens, or doves from the attacks of predatory mammals? If so, how many and what kinds were killed on each occasion? In each case mention the animal by which you suppose the mischief was done, and your reasons for this belief.
3. What mammals, if any, steal feed put out for poultry?

To farmers, fruit-growers, and gardeners.

4. What mammals, if any, are injurious to grain crops in your neighborhood? In each case state whether the injury is occasioned directly by the consumption or the trampling of the grain, or by tunnels underneath the surface. Is the loss thus occasioned of trifling or serious consequence?
5. What mammals, if any, are injurious to fruit, and what kind or kinds of fruit are eaten by each species? Is the loss thus occasioned of trifling or serious consequence?
6. What mammals, if any, are injurious to vegetables, and what kind or kinds of vegetables are eaten by each species? Is the loss thus occasioned of trifling or serious consequence?
7. What mammals, if any, are injurious to meadows and pastures? In what manner are the injuries committed? Is the loss thus occasioned of trifling or serious consequence?
8. Are your fields subject to periodical invasions of Meadow Mice (*Arvicolæ*)? If so, can you give the exact dates of one or more of such invasions?
9. What mammals, if any, are injurious to forest, shade, fruit, or ornamental trees or shrubs? What kind or kinds of trees or shrubs are injured by each, and in what manner, and at what season is the damage done? Is the loss thus occasioned of trifling or serious consequence?
10. Have you personal knowledge of an instance in which cattle or horses have been injured by stepping into the burrows of Woodchucks, Muskrats, or Badgers? If so, give particulars.
11. What mammals, if any, are beneficial to the farmer? In what manner are these benefits derived?

To rice-growers.

12. Are rats troublesome on your plantation? If so, are they injurious by feeding directly upon the newly-planted rice, or by burrowing in the dikes, or both? Can you estimate the annual pecuniary loss thus occasioned?
13. Do any other small mammals affect the interests of the rice-grower? If so, what kind or kinds, and to what extent?

To hop-growers.

14. What mammals, if any, affect the interests of the hop-grower? In what manner and to what extent are these effects manifested?

Miscellaneous.

15. Is the common mouse about dwellings, barns, and out-buildings in your neighborhood the White-footed or the House Mouse, or are both present? In the latter case, which is most abundant? If uncertain as to the species, please send a specimen (the head will suffice) to the Department for identification.
16. What mammals, if any, injure or deface buildings, household goods, books, or papers?
17. What mammals, if any, injure canals or other embankments, dams, dikes, or drains? Is the damage thus occasioned of serious or trifling consequence?
18. In your opinion, are Moles beneficial or injurious? On what facts is this opinion based?

NOTE.—Meadow Mice, or "Voles," must not be confounded with Moles.

19. In your opinion, are Skunks beneficial or injurious? On what facts is this opinion based?

20. Do you know of one or more instances in which the increase of a species of economic importance has been limited by the abundance of its natural enemies? If so, give particulars.

In the Mississippi Valley, and the region between it and the Pacific, numerous small rodents called Gophers do great damage to farms and crops. There are two principal kinds, Pocket Gophers, which live mostly under ground, and are characterized by external cheek-pouches and unusually large fore-claws (*Geomys* and *Thomomys*), and Gophers or Ground Squirrels, which live mostly above ground, and have neither external cheek-pouches nor claws of unusual size (*Spermophilus* and *Tamias*). Of these the common little Striped Gopher (*Spermophilus tridecemlineatus*) and the large gray "Line-tailed" Spermophile (*Spermophilus grammurus*) and its varieties are most abundant and widely distributed, and occasion the greatest losses to grain crops. Numerous other species, more or less local, affect the farmer's interests very appreciably.

Detailed information is desired concerning the habits and ravages of all these Gophers. Such information should be accompanied by a specimen (a rough skin will suffice) for positive identification.

The above remarks apply with equal force to the various small mammals known as Kangaroo Rats and Mice, Pocket Rats and Mice, Wood Rats and Mice, &c.

In answering this circular please mention your occupation. If a farmer, state the size and character of your farm, and mention the principal crops which you cultivate.

Write your name and post-office address as plainly as possible.

[Circular No. 4.]

INSTRUCTIONS FOR THE COLLECTION OF STOMACHS.

In investigating the economic relations of birds and mammals it is necessary to determine with accuracy the character of the food upon which the various kinds subsist. This is particularly important in the case of species which are known to exert an influence, beneficial or otherwise, upon certain farm and garden crops. Hence the Department of Agriculture desires to secure a collection of the stomachs and gizzards of our native mammals and birds, particularly of those which are supposed to affect agricultural interests.

Method of preparation.

All specimens should be preserved in 90 per cent. alcohol.

A stout paper tag should be attached to each stomach or gizzard by means of a strong thread or fine wire, which should be passed directly through its substance. Each tag should be numbered (in hard pencil) to correspond with the number given the specimen on the accompanying blank. Some birds, particularly in the breeding season, carry food in the gullet or crop. In such cases these portions of the alimentary tract should be preserved, and should bear the same number that is given the gizzard of the same individual.

Stomachs of the following species are especially desired:

Birds.—Hawks, Owls, Crows, Jays, Blackbirds, Cowbird, Shrikes, Cuckoos, Carolina Dove, Woodpeckers, Quail, English Sparrow, Bobolink or Rice-bird, Kingbird or Bee Martin.

Mammals.—Fox, Skunk, Mink, Weasels, Badger, Raccoon, Opossum, Squirrels, Ground Squirrels, Gophers, Mice, Moles, Shrews, Bats.

In the case of Mice, Moles, Shrews, and Bats, the entire animal should be sent, in order that the species may be fully identified.

A number of specimens may be preserved in a single wide-mouthed bottle or jar.

Persons willing to aid in the collection of stomachs will be furnished with blanks on which to record the necessary data.

Transportation charges will be paid by the Department.

[Circular No. 5.]

CIRCULAR TO RICE-GROWERS.

The Department of Agriculture desires the co-operation of rice-growers in its attempt to secure trustworthy information concerning the extent of the injury annually done the rice crop by certain birds, chiefly the Bobolink or Rice-bird and the Red-winged Blackbird; and in devising some measure or measures, consistent with reasonable economy, for the diminution, if not the prevention, of this loss.

Information in reply to the following questions is solicited:

1. Are you a rice planter?
2. If so, how many acres have you under cultivation?
3. What is the average yield of rice per acre?
4. What do you consider a fair estimate of the average annual loss per acre occasioned by birds?
5. Please cite a few extreme cases.
6. What percentage of this loss is due directly to the value of the rice consumed, and what indirectly to the cost of gathering and thrashing the worthless grain?
7. What is the average annual cost per acre of measures employed for the prevention or diminution of this loss?
8. In addition to the use of fire-arms and whips, what measures, if any, are employed for this purpose?
9. How many "bird-minders" are employed annually upon your plantation during the fall invasion of Rice-birds?
10. How many pounds of gunpowder are consumed annually during this period?
11. Is shot now used on your plantation? If so, in what quantity?
12. What kind or kinds of birds are most destructive to rice?
13. At what time of the year and for how long a period are these birds present?
14. What is the greatest number of Rice-birds that you have known to be killed in a single season?
15. Does the rice crop on your plantation sustain a loss from the depredations of birds at time of planting in spring? If so, what is the average loss per acre at this time?

Any information relating to the subject, though not covered by the above questions, will be thankfully received.

In some cases the above circulars were accompanied by schedules. The number of each distributed will appear in the following statement:

CIRCULARS AND SCHEDULES DISTRIBUTED.

Circulars:		
On the food-habits of birds	4,000	
On the English Sparrow	4,000	
On the economic relations of mammals	2,500	
On the collection of birds' stomachs	600	
To rice-growers	600	
		11,700
Schedules:		
On the English Sparrow	5,000	
On migration	1,500	
Stomach blanks	500	
		7,000
Total of circulars and schedules distributed from July 1 to December 10, 1886		18,700

This number does not include circular letters, of which 2,345 have been sent out; making 21,045 in all.

The correspondence of the division is so large that it is very burdensome. More than four thousand letters were acknowledged during the six months ending December 31, 1886.

At the outset it was seen that two birds pre-eminently claimed the immediate attention of the division, namely, the so-called English Sparrow (*Passer domesticus*), and the Bobolink or Rice-bird (*Dolichonyx oryzivorus*). These birds, by their numerical abundance, the extent of the damages they were said to cause at certain times of the

year, and the widespread difference of opinion in regard to their economic status as a whole, demanded searching and systematic investigation; hence they have been made subjects of special research.

Cock Sparrow. (From Yarrell.)

THE ENGLISH SPARROW (*Passer domesticus*).*

Questions relating to the English Sparrow were contained in the first circular on economic ornithology issued by the Department (in July, 1885). Subsequently these questions were amplified, and during the current year a special circular and schedule were prepared, upwards of five thousand copies of which have been distributed. To date, replies have been received from about thirty-two hundred persons. They contain a vast amount of valuable information, which is now being collated for publication. In order to be able in future years to determine the rate of spread of the Sparrow over regions which it does not now occupy, the Department has ascertained, with as much precision as possible, the exact limits of its distribution at the present time, and has shown the same by means of the accompanying colored map. In addition to the material collected by the Department of Agriculture, the American Ornithologists' Union has turned over to the division the results of its investigations, begun in 1883, on the eligibility or ineligibility of the European House Sparrow in America. This material has been since collated and arranged by Dr. F. H. Hoadley, who, from interest in the subject, kindly volunteered his services.

In advance of the publication of the special bulletin on the English Sparrow question, which will contain in detail the evidence on which the following statements are based, it is thought desirable at the

*The true name of this bird is the "House Sparrow." The name "English Sparrow" is a misnomer, as the species is not confined to England, but is native to nearly the whole of Europe. The fact that most of the birds brought to America came from England explains the origin of the misleading name by which it is now so widely and universally known that any attempt to change it would be futile.

present time to set forth some of the results of the investigation for the information of the general public, and to make certain recommendations to the legislative bodies of the various States, in order that they may enact, at as early a date as possible, such laws as are demanded for the protection of their agricultural industries.

Introduction of the English Sparrow.

The English Sparrow was first brought to this country, so far as authentic information has reached the Department, in the fall of 1850, when the Hon. Nicolas Pike and other directors of the Brooklyn Institute imported eight pairs into Brooklyn, N. Y. They were artificially housed over winter and liberated early in the following year; but they did not thrive. In 1852 a larger colony was imported. These birds are said to have multiplied and spread over Long Island and adjacent parts of New York and New Jersey. In 1858, and at subsequent dates, independent importations were made, and colonies were planted in Portland, Me.; Peacedale, R. I.; New York, Philadelphia, and other Eastern cities. In most cases the birds did well. They multiplied and spread gradually to neighboring towns. But the process of diffusion was slow at first, and it was not until 1870 that the species can be said to have firmly established itself throughout the Eastern States, and to have begun in earnest its westward march. From this time to the present, the marvelous rapidity of its multiplication, the surpassing swiftness of its extension, and the prodigious size of the area it has overspread are without parallel in the history of any bird. Like a noxious weed transplanted to a fertile soil, it has taken root and disseminated itself over half a continent before the significance of its presence has come to be understood. The explanation of this phenomenal invasion must be found in part in the peculiar impetus usually given prolific species when carried to a new country where the conditions for existence are in every way favorable; and in part in its exceptional adaptability to a diversity of physical and climatic conditions. This adaptability has enabled it not only to endure alike the tropical heat of Australia and the frigid winter of Canada, but to thrive and become a burdensome pest in both of these widely separated lands.

The English Sparrow is a hardy, prolific, and aggressive bird, possessed of much intelligence and more than ordinary cunning. It is domestic and gregarious in habit, and takes advantage of the protection afforded by proximity to man, thus escaping nearly all of the enemies which check the abundance of our native birds. Moreover, for many years it was looked upon with favor, and both food and shelter were provided it.

Rate of increase of the Sparrow.

Its fecundity is amazing. In the latitude of New York and southward it hatches, as a rule, five or six broods in a season, with from four to six young in a brood. Assuming the average annual product of a pair to be twenty-four young, of which half are females and half males, and assuming further, for the sake of computation, that all live, together with their offspring, it will be seen that in ten years the progeny of a single pair would be 275,716,983,698. This will appear in detail from the following:

Table showing the annual increase and the total number of English Sparrows, the progeny of a single pair, in successive seasons for ten years, assuming that all lived.

Years.	Number of pairs breeding.	Number of pairs of young.	Total number of pairs.	Total number of birds.
First	1	12	13	26
Second	13	156	169	338
Third	169	2,028	2,197	4,394
Fourth	2,197	26,364	28,561	57,122
Fifth	28,561	342,732	371,293	742,586
Sixth	371,293	4,455,516	4,826,809	9,653,618
Seventh	4,826,809	57,921,708	62,748,517	125,497,034
Eighth	62,748,517	754,982,204	815,730,721	1,631,461,442
Ninth	815,730,721	9,788,768,652	10,604,499,373	21,208,998,746
Tenth	10,604,499,373	127,253,992,476	137,858,491,849	275,716,983,698

Method of diffusion of the Sparrow.

"As the towns and villages become filled to repletion the overflow moves off into the country, and the Sparrow's range is thus gradually extended. Occasionally, however, it is suddenly transported to considerable distances by going to roost in empty box-cars and traveling hundreds of miles. When let out again it is quite as much at home as in its native town. In this way it reached St. John, New Brunswick, in 1883, on board the railroad trains from the west. In like manner another colony arrived March 1, 1884, in grain cars from Montreal. Similarly it appeared at Moncton, Frederickton, and Saint Stephen, in Canada, and in a number of towns in the United States." (Hoadley MS.)

Aside from this accidental means of wide dispersion, small colonies have been purposely carried from time to time to various localities beyond the limit of its regular advance, and these in turn have become centers of diffusion. Prominent examples of this sort may be seen in the large colonies now inhabiting California, the basin of the Great Salt Lake, and the region bordering the Lower Mississippi, in Louisiana.

The method by which the Sparrows spread without the aid of man is peculiar. They first invade the larger cities, then the smaller cities and towns, then the villages and hamlets, and finally the populous farming districts.

Rate of spread of the Sparrow, and extent of area occupied at the close of the year 1886.

In the year 1886 the English Sparrow was found to have established itself in thirty-five States and five Territories. Of these it occupies the whole or large parts of the following thirty-three States and two Territories: Alabama, Arkansas, California, Connecticut, Delaware, District of Columbia, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Utah, Vermont, Virginia, West Virginia, and Wisconsin, and is found in a few towns in Florida, Texas, Wyoming, Idaho, and Arizona. Small, isolated colonies may exist in a few other Territories, but if so they have escaped the searching inquiry of the Department. In the United States the total area occupied at the close of the year 1886 is 885,000 square miles; in Canada it is not quite 148,000 square miles; in all, 1,033,000 square miles.*

*The data on which the computation of the Canadian area is based are insufficient, consequently the size of the area here given must be regarded as approximate only. The United States area, however, may be looked upon as very nearly exact.

Some idea of the alarming rapidity with which it is at the present moment multiplying and extending its range may be had from the fact that in the United States alone it has spread during the past fifteen years at the average rate of 59,000 square miles per year, and in the United States and Canada together at the rate of 69,000 square miles per year. But this *average* rate manifestly is misleading, so far as both extremes are concerned, for species increase in geometrical ratio. The rate for some time after 1870 was comparatively slow, while during the present decade it has progressed with astonishing rapidity, till in the year 1886 the new territory invaded must have reached the enormous number of 516,500 square miles, as may be seen from the following:

Table showing approximately the extension in square miles of the English Sparrow, in periods of five years each, from 1870 *till* 1885, *and its extension during the year* 1886.*

	Square miles.
From 1870 to 1875 it spread over	500
From 1875 to 1880 it spread over	15,640
From 1880 to 1885 it spread over	500,760
In the year 1886 it spread over	516,500

The Sparrow an enemy of our native birds.

Of all the native birds which habitually make their homes near the abodes of man, the Martin is the only species which is able to hold its own against the Sparrows, and numerous instances are on record where even the Martin has been beaten and forced to abandon its former nesting-places by these belligerent aliens. It sometimes happens that the Martin is killed outright, as appears from the following account, just received from Prof. F. H. King, of River Falls, Wis.:

> Mr. H. T. Baker, of Berlin, Wis., has related to me that last summer he was a witness of a conflict between some English Sparrows and Purple Martins, in which the Sparrows were trying to get possession of breeding-places which had been occupied for several years by the Martins. The Sparrows had congregated in a large flock upon a tree standing near a building, in the cornice under the eaves of which the Martins had their nests. From this point a number of Sparrows would together attack the Martins, and then return to the tree, to be followed by a similar squad. This method of attack was followed until three Martins had been killed, some of the Martins having had their eyes picked out. It need hardly be added that the Martins were forced to leave. The same gentleman tells me that he saw the Sparrows kill in the same manner a bird, the name of which he did not know, in the city of Milwaukee.

The birds which have suffered most from the English Sparrow, and whose cheery presence in the parks and lawns in the nesting season we no longer, or only rarely, enjoy are the Robin, Catbird, Bluebird, Wren, Song Sparrow, Chipping Sparrow, Yellow-bird, Oriole, Vireo, and Phœbe. Not only does the Sparrow drive away and sometimes kill the adult birds, but when it finds their nests it throws out the eggs and young, and not infrequently feasts upon them. Dr. B. Harry Warren, State ornithologist of Pennsylvania, writes:

> Our native birds have rapidly and steadily diminished in numbers since the Sparrows came. Former plentiful residents are rare. Even transient visitants and migrants have been so pursued by the usurper that they now seem to avoid West Chester as a plague-stricken spot. In 1877 I saw two Cock Sparrows attack a nest

* This table of necessity is largely theoretical, though the ratio of increase must be very nearly correct. Year by year much of the reproductive energy of the Sparrow is expended in filling up the smaller towns and villages of the area which, so far as the larger towns and cities are concerned, it covered some time previously.

of the Warbling Vireo in the absence of the parent birds, pull out one at a time the four half-fledged occupants, and drop them on the ground. After partly destroying the nest the Sparrows alighted on the ground beside their victims, and, being re-enforced by several of their kin, proceeded to enjoy the sanguinary repast.

Numerous parallel cases have been reported, and will be published in the bulletin on the Sparrow question.

The Sparrow an enemy to the gardener and fruit-grower.

In addition to the indirect injury thus brought about by depriving our gardens and orchards of the protection afforded by our native insectivorous birds, the Sparrows cause a positive and direct loss to our agricultural industries amounting in the aggregate to not less than several millions of dollars per annum. The damage done by the Rice-bird is limited to a single crop, and takes place during a few weeks in spring and fall, but the ravages of the English Sparrow affect almost every crop produced by the farmer, fruit-grower, and truck gardener, and extend over the entire year. Indeed, it is safe to say that it now exerts a more marked effect upon the agricultural interests of this country than any other species of bird; and its unprecedented increase and spread, taken in connection with the extent of its ravages in certain districts, may be regarded with grave apprehension. In the early spring it prevents the growth of a vast quantity of fruit by eating the germs from the fruit-buds of trees, bushes, and vines, of which the peach, pear, plum, cherry, apple, apricot, currant, and grape suffer most.

"Lettuce, peas, beets, radishes, cabbages, and cauliflower are attacked in turn, and devoured as soon as they show their heads above the ground, and in many cases the seed is taken out of the earth before it has germinated. So extensive is the injury thus done, that in many localities it has been found necessary to cover the garden-beds with netting. Whenever the buds are so fortunate as to escape, the ripening fruit appeals strongly to the Sparrow's appetite, and different varieties are attacked, injured, or destroyed in turn as they mature. All sorts of garden products, vegetables, berries, grapes, and even the larger fruits, are greedily fed upon or mutilated to such an extent as to unfit them for market. The magnitude of the havoc wrought in orchards and vineyards is shown by the melancholy accounts given by fruit-growers in every section of the country where it has become numerous." (Hoadley MS.)

Mr. Jabez Webster, of Centralia, Ill., writes:

I have seen flocks of fifty or more stay about my raspberries, constantly flying backwards and forwards, taking quarts of the best fruit, and coming very close to the pickers.

Mr. W. C. Percy, of Black Hawk, La., writes:

They destroy more tomatoes, peas, beans, &c., than any other bird. In 1884 and 1885 they ruined the peach and apple crop.

Mr. John H. Strider, of Halltown, W. Va., writes:

It nips fruit blossoms, destroys early peas and cabbages, and later in the season garden seeds; is very destructive to sunflower seed.

Norman A. Wood, of Saline, Mich., writes:

They eat green peas as fast as they grow; also raspberries, blackberries, and strawberries.

H. H. Beeson, of New Market, N. C., writes:

They peck grapes, strawberries, tomatoes, plums, peaches, and pears, causing them to decay.

Mr. F. M. Webster, of La Fayette, Ind., writes:

The English Sparrow is destroying my apples. I have two or three trees in my garden, and as soon as the fruit gets mellow the Sparrows peck holes in it, and it

either drops to the ground or decays on the trees. These birds are worse than all other apple pests combined. I can hardly get a single apple fit to eat; they have destroyed nearly if not quite three-fourths of them. A neighbor across the way is troubled in the same manner.

An apple pecked as above described and kindly sent to the Department by Mr. Webster is figured in the accompanying cut.

APPLE PECKED BY ENGLISH SPARROWS.

From orchard of F. M. Webster, Lafayette, Indiana, October 7, 1886.

The Sparrow an enemy to grape culture.

The grape industry, which is one of rapidly increasing consequence in this country, encounters in the English Sparrow an enemy second only to the *Phylloxera* and certain fungus growths. Already in some parts of the East it has become such a scourge that grape culture can no longer be carried on with profit, it being necessary to inclose the ripening clusters in bags to insure their protection. At the end of the season of 1886 bitter complaints of damage done the grape crop by Sparrows had reached the Department from twenty-five States and the District of Columbia, as follows: Alabama, Arkansas, California, Connecticut, District of Columbia, Georgia, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Mississippi, New Jersey, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Vermont, Virginia, and West Virginia.

In California, where this industry is of paramount importance, the English sparrow has taken firm root and is multiplying and spread-

ing with ominous rapidity; and unless steps are taken to wipe out the pest at the earliest possible moment the result will entail a loss to the State of many thousands, if not millions, of dollars. In this connection it is not reassuring to read, in the evidence collected and published by the Australian Government in 1881, that "in the short space of ten days the Sparrows took a ton and a half of grapes" from the vineyard of John Chambers, of South Richland. Of the hundreds of testimonials which have been sent the Department of Agriculture by practical fruit-growers, the following are suggestive examples:

Mr. F. S. Platt, of New Haven, Conn., writes:

Last year, when I had a large crop of very fine grapes, I found that the Sparrows were destroying nearly all of them. I watched the birds, and found that they would pick out a fine bunch of fruit and peck a hole in nearly every grape. This hole would be so very small that at first it would not be noticed, but very soon the place would begin to decay, and then the grape would be ruined.

The postmaster at Bowling Green, Ky., writes:

It has ruined the grape crop almost wholly where unprotected.

Mr. Witmer Stone, of Germantown, Pa., writes:

It frequently despoils whole grape-vines of their fruit, and pecks the bunches so that they have to be protected by paper bags.

Mr. Thomas S. Kennedy, of Crescent Hill, Ky., writes:

It eats strawberries, raspberries, and grapes. This past season it has been unusually destructive, and has torn the paper bags from the bunches of grapes. It also eats holes in apples and pears hanging on the trees.

The Sparrow an enemy to the grain-grower.

"Annoying and injurious as the Sparrow is to the fruit-grower and vegetable gardener, the loss it inflicts on the producer of cereals is even greater. Though for its permanent residence it prefers populous localities and places of abundant traffic and commotion, still, in anticipation of the harvest season, it gathers in enormous flocks, and, leaving the cities and towns, moves off into the surrounding country to feed upon the ripening grain. Its consumption and waste of corn, wheat, rye, oats, barley, and buckwheat in many parts of the country is enormous. It feeds upon the kernel when it is in the soft, milky state, as well as when it has matured and hardened; and in fields of ripe grain it scatters upon the ground even more than it consumes. Instances have been reported where in the place of a full or fair crop only the straw remained to be gathered."—(Hoadley MS.)

Mr. Andrew Gray, of Willoughby, Ohio, in a recent letter to the Commissioner of Agriculture, states:

This is to inform you that I drilled in the seed-wheat which you sent me. I sowed it on rich sandy soil, and it came through the winter well and gave promise of a splendid crop, especially the Diehl Mediterranean, which looked the most promising, although the Martin Amber did very well. But alas for human hopes! About four or five days before it was ready to cut I went to see how it was getting along, and found that the English Sparrows had harvested the crop. Their first choice was the Martin Amber, the next was the Diehl Mediterranean, and the last the Clawson. I saved about a peck of seed. I think I can safely say that I would have got as much as one and one-half bushels of seed from the two quarts of seed you sent me if the Sparrows had let it alone.

Mr. William Holmead, of Mount Pleasant, D. C., whose business it is to raise fruits, vegetables, and grain for the market, writes:

In 1882 I put part of my farm in wheat. After cutting and shocking it the Sparrows came by thousands and destroyed every head of grain exposed; after it was stacked preparatory to thrashing they covered the whole stack. I had to shoot at them two or three times a day to scare them away, and upon thrashing it was estimated that fully one-tenth of the crop was destroyed. One of my neighbors estimated that one-half of his wheat was eaten by the Sparrows last year. This year I had about four acres in oats. When the oats were put in the barracks the field was filled with thousands of Sparrows, and when they had cleaned the field they attacked

the oats in the barracks and destroyed all that was exposed. Sugar and field corn when green are very much damaged by them. They tear the ends of the ears and eat the corn in the same manner as Crows.

Dr. B. Harry Warren, State ornithologist of Pennsylvania, writes:

The Sparrow greatly damages the corn crop, tearing open the husks, devouring the tender part of the ear, and exposing the remainder to the ravages of insects and to atmospheric changes. It alights on fields of wheat, oats, and barley, consuming a large quantity, and, by swaying to and fro on the slender stalks and flapping its wings showers the remainder on the ground.

Mr. S. M. Clark, of the District of Columbia, states:

The Sparrows stripped my entire crop of pearl millet, not leaving a kernel on the ear.

Mr. Robert Ridgway, ornithologist of the United States National Museum, writes:

In the summer of 1886 I saw flocks of hundreds of English Sparrows feeding on grain in stacks in Prince William County, Virginia; have also seen the same elsewhere.

Mr. Frank S. Platt, of New Haven, Conn., writes.

Cradled a small piece of oats, and the Sparrows gathered on the shocks in such flocks that I shot fifty-four with one barrel and thirty-five with the other. In our seed gardens we had to keep a boy all the time to prevent waste of turnip, cabbage, and other seeds.

Mr. John Cordeaux, the veteran ornithologist of England, says he has seen acres of grain which had the appearance of having been thrashed with a flail after it had been invaded by the Sparrows.

Already the English Sparrow has invaded the rice fields in certain parts of the South, where it threatens to rival the Bobolink in the extent of its ravages. Indeed, one planter writes from Plaquemines Parish, Louisiana, that it is more destructive now than the Rice-bird or Blackbird.

Effect on architecture, and defilement of buildings.

"That the Sparrow exerts a very appreciable influence on architecture can be readily observed in the modifications which its presence has rendered necessary in cornices, gables, jutting portions of roofs, and the various devices made use of in the elaboration and embellishment of edifices, both public and private."—(Hoadley MS

In addition to the disfigurement of buildings by the nests and excrement of the Sparrows, and the injury to ornamental trees and shrubs resulting from the same cause, it should be mentioned that they frequently damage and sometimes destroy the ivy and woodbine covering the walls of churches and other edifices.

Mr. Robert Ridgway, of the Smithsonian Institution, says:

The Sparrows injure ornamental vines, &c., by chemical action of their excrement. The luxuriant English ivy that once covered portions of the Smithsonian building was thus totally destroyed by them.

Mr. Eli Whitney Blake, 3d, of Providence, R. I., writes:

The sexton of St. John's church, in this city, took 970 eggs and two cart-loads of nests *at one time* from the ivy covering the walls of that church.

Failure of the Sparrow as an insect-destroyer.

The English Sparrow was brought to this country in the belief that it was an insectivorous bird, and with the expectation that it would rid our cities of the caterpillars which destroy the foliage of the elms and other shade trees in the streets and parks. The utter futility of this hope has been demonstrated over and over again in hundreds of

our cities and larger towns which are overrun with Sparrows, and where the trees have been repeatedly defoliated and disfigured by the worms. Cases are known in which the very boxes occupied by the Sparrows have been covered with webs, where the cocoons have been attached to the boxes, and the larvæ have hatched and crawled away within a few inches of the birds without molestation. Indeed, it is an every-day occurrence in summer to see Sparrows hopping about on fences and branches fairly swarming with caterpillars and measure-worms, in whose presence they rarely manifest the slightest interest. It is true that they destroy some insects, particularly when feeding their young, but it would be presumptuous to say that the number thus destroyed is greater than the number consumed by the truly insectivorous birds which the Sparrows have driven away.

English Sparrows cause an increase in the number of caterpillars.

Prof. J. A. Lintner, State entomologist of New York, has made a special study of the cause of the increase of the caterpillars of the tussock moth (*Orgyia leucostigma*), which is very destructive to the foliage of shade and fruit trees and ornamental shrubs. The results of Professor Lintner's investigations, extending over a period of years, have led him to make the following unqualified statement:

The extraordinary increase of the *Orgyia leucostigma* is owing to the introduction and multiplication of the English Sparrow.

His subsequent remarks under this head are so valuable, that I make no apology for introducing them in full. He says:

This may seem a strange statement, in consideration of the fact that the Sparrow was imported from Europe for the express purpose of abating the "caterpillar nuisance" in New York and some of the New England cities. * * * The increase of the *Orgyia leucostigma* commenced and has continued to progress with that of the Sparrow.

A remark made to me that the caterpillars had been observed to be very numerous in localities where the Sparrows also abounded induced me to undertake to verify or disprove the idea that had suggested itself to me, that the Sparrow afforded actual protection to the caterpillars and promoted their increase.

In a locality in the city [of Albany, New York] (intersection of Broadway and Spencer streets) which I had traversed daily during the preceding year, I had been interested in watching the habits of a large company of Sparrows, which had established themselves in quarters evidently in every way suited to their taste and wants, among the vines and leaves of a large woodbine (*Ampelopsis quinquefolia*), which covered with a dense matting nearly the entire side of a large dwelling. Here I had observed a greater number of the Sparrows than elsewhere in the city. They were still local, and far from being generally distributed.

Upon visiting this locality for the purpose above mentioned, I found upon the other side of the building, and on an adjoining one, three other large woodbines not before noticed by me, making five in all. On a tall pole standing between the two buildings a very large sparrow-house, with many compartments, had been erected, and many smaller ones had been placed among the branches of the trees. The woodbines seemed alive with the Sparrows. Hundreds were issuing from them and dropping down to their favorite stercoraceous repasts in the streets, and the air was vocal with their chattering. It was a rare bird exhibition. Here certainly was a test case of the insectivorous nature of the Sparrow.

On the sidewalk in front of the two buildings two large spreading elms (*Ulmus Americanus*), standing between some maples, showed *every leaf eaten from them*, disclosing the nesting-boxes among their branches, and their trunks and limbs dotted thickly or clustered with the easily recognized egg-bearing cocoons of the *Orgyia*. Hundreds of immature caterpillars were traveling over the trees, fences, and the walls adjoining. No better evidence of the almost perfect immunity afforded to the caterpillars from their enemies, whether birds or insects, by the presence of the Sparrows, could possibly be given.

A portion of Broadway, between Clinton avenue and the Central Railroad crossing, was also known to abound in the Sparrows, the citizens resident there having fed

them most generously, not only during the winter season, but also in the summer months. Nesting-boxes had been placed for them in most of the trees. Here the trees presented a pitiable sight. Many of the elms and horse-chestnuts were entirely stripped of their foliage; the naked ribs of the leaves of the latter seemed ghastly in their suggestion of fleshless fingers. Nowhere else in the city had I seen such ravages.

Passing thence to Pearl and State streets, the same association of Sparrows, caterpillars, and their destructive work was seen. Clinton Square, where the Sparrows had, in their introduction into the city, been specially taken under the care and protection of the residents on the east side of the park, afforded another excellent test. It was evident that the Sparrows were in full appreciation of their privileges from the almost incredible numbers sporting about the trees. Their protégés were also in full force. Caterpillars and their cocoons met the eye everywhere, while hanging from the rails and caps of the iron fence surrounding the park were the dead and decomposing bodies of caterpillars killed by the recent heavy rains (often so fatal to insect larvæ), in such numbers that they tainted the air in their vicinity.

It seems unnecessary to extend this record further than to add that in other sections of the city observations made were in accord with the above.

HOW THE SPARROWS PROTECT THE CATERPILLARS.

That the Sparrows decline to eat the Orgyia caterpillar is not a charge against them. They *could not* eat them with impunity. The diet would doubtless prove fatal to them. The charge to which they are amenable is this: By the force of numbers, united to a notoriously pugnacious disposition, they drive away the few birds that would feed upon them. Of these we know but four species, viz: The Robin (*Merula migratoria*), the Baltimore Oriole* (*Icterus galbula*), the Black-billed Cuckoo (*Coccygus erythropthalmus*), and the Yellow-billed Cuckoo (*Coccygus Americanus*). The above species seem, in the ordering of nature, to have been assigned to us for protection from an undue multiplication of a large number of hairy caterpillars of injurious habits. * * * One of them, the Yellow-billed Cuckoo, is known to shave off the hairs of the *Orgyia leucostigma* caterpillar before swallowing it. The following account of the operation is from Dr. Le Baron, former State entomologist of Illinois: "My attention was attracted to a Cuckoo regaling himself upon these caterpillars, which were infesting in considerable numbers a larch growing near the house. My curiosity was excited by seeing a little cloud of hair floating down upon the air from the place where the bird was standing. Upon approaching a little nearer I could see that he seized the worm by one extremity, and, drawing it gradually into his mouth, shaved off, as he did so, with the sharp edge of his bill the hairy coating of the caterpillar and scattered it upon the wind."

Under the head of Preventives and Remedies, Professor Lintner advises "a relentless war upon the English Sparrows," and states that the removal of this bird "would also serve to diminish the losses annually sustained in our orchards, forests, and gardens from the following well-known noxious species: The apple-tree tent-caterpillar (*Clisiocampa Americana*), the forest tent-caterpillar (*Clisiocampa sylvatica*), the fall web-caterpillar (*Hyphantria textor*), the yellow-necked apple-tree caterpillar (*Datana ministra*), the yellow wooly-bear (*Spilosoma virginica*), and many others of the kind." (Second report on the Injurious and other Insects of the State of New York, by J. A. Lintner, Albany, 1885, pp. 80–83.)

Miss Eleanor A. Ormerod, consulting entomologist to the Royal Agricultural Society of England, in her ninth report on Injurious Insects and Common Farm Pests for 1885, states that the Sparrows drive off Swallows and Martins, thus permitting a great increase in flies and insects "destructive in the garden and orchard." Miss Ormerod cites a case in which the destruction of the Sparrows and consequent reappearance of Swallows and Martins resulted in the abolishment of the insect pest.

*This bird has been seen with its head thrust into the web-nest of the tent-caterpillar, eagerly devouring its occupants.

Mr. J. H. Gurney, Jr., a well-known British ornithologist, says:

I think they do enough harm to warrant everybody in destroying them. Say one-fifth of good to four-fifths of harm is about what they do, take the country all over, *though at certain times and places they do nothing but harm.* I have striven to say all I could in their favor, being naturally a lover of birds.

The destructive habits of the English Sparrow in Bermuda, Cuba, England, Germany, Austria, Russia, India, Egypt, and Australia are too well known to require more than passing observation. In England alone the damage it causes has been estimated as not less than $3,850,000 per annum, and in Australia the loss is much greater. It threatens to become a more baneful pest to the American farmer and horticulturist than the grasshopper, caterpillar, and Colorado beetle.

Recommendations for legislation.

The following recommendations are respectfully submitted to the legislative bodies of the various States and Territories:

(1) The immediate repeal of all existing laws which afford protection to the English Sparrow.

(2) The enactment of laws legalizing the killing of the English Sparrow at all seasons of the year, and the destruction of its nests, eggs, and young.

(3) The enactment of laws making it a misdemeanor, punishable by fine or imprisonment, or both—(*a*) to intentionally give food or shelter to the English Sparrow, except with a view to its ultimate destruction; (*b*) to introduce or aid in introducing it into new localities; (*c*) to interfere with persons, means, or appliances engaged in, or designed for, its destruction or the destruction of its nests, eggs, or young.

(4) The enactment of laws protecting the Great Northern Shrike or Butcher Bird, the Sparrow Hawk, and the Screech Owl, which species feed largely on the English Sparrow.

(5) The enactment of laws providing for the appointment of at least one person holding civil office, preferably the game constable, where such officer exists, in each town or village, who shall serve without additional compensation, and whose duty it shall be to destroy or bring about the destruction of English Sparrows in the streets and parks and other places where the use of fire-arms is not permitted. In the larger towns and cities this office might be well imposed upon the commissioners of public parks.

It is not expedient to offer bounties for the destruction of Sparrows. In fact, at the present time it is desirable, and perfectly feasible, to bring about a great reduction in their ranks by concerted action of the people, aided by helpful legislation, without drawing upon the public purse.

Recommendations to the people.

The English Sparrow is a curse of such virulence that it ought to be systematically attacked and destroyed before it becomes necessary to deplete the public treasury for the purpose, as has been done in other countries. By concerted action, and by taking advantage of its gregarious habits, much good may be accomplished with little or no expenditure of money.

The Sparrow is a cunning, wary bird, and soon learns to avoid the means devised by man for its destruction. Hence much sagacity must be displayed in the warfare against it. In the winter-time, if

food is placed in some convenient spot at the same hour each day for a week, the Sparrows will gather in dense flocks to feed, and large numbers may be killed at one time by firing upon them with small shot. Sometimes they may be successfully netted or trapped, but this requires considerable skill. They may be poisoned by grain soaked in tincture of nux vomica or in Fowler's solution of arsenic, but poisoning is attended with some danger, and should be attempted only by official sparrow-killers.

Large numbers may be destroyed and increase prevented by the systematic destruction of their nests, eggs, and young. By the aid of an iron rod and hook, set in the end of a long pole, most of their nests can be reached and brought down. This method promises most satisfactory results.

They may be easily driven from their roosting-places by disturbing them on several successive nights. A very efficacious method is to throw water upon them when at roost. In cities where hose-pipe is available the process is simple and certain. They may be kept out of ornamental vines in the same manner, particularly in the breeding season, when a thorough soaking not only disconcerts the old birds and kills their young, but at the same time does much good by wetting the vines and washing out their filth.

The Sparrow as an article of food.

In this connection it should not be forgotten that the English Sparrow is an excellent article of food, equaling many of the smaller game birds. In fact, at restaurants it is commonly sold under the name of "Rice-bird," even at times of the year when there are no Rice-birds in the country.

Prof. J. A. Lintner, State entomologist of New York, informs me that English Sparrows are now sold largely in the market at Albany, N. Y., "one dealer reporting a monthly sale of about 2,000."

RAVAGES OF RICE-BIRDS.

One of the most important industries of the Southern States, the cultivation of rice, is crippled and made precarious by the bi-annual attacks of birds. Many kinds of birds feed upon rice, but the bird which does more injury than all the rest combined is the Bobolink of the North (*Dolichonyx oryzivorus*), called "Reed-bird" along the Chesapeake, and "Rice-bird" in the South.

Next in importance after the Bobolink is the Red-shouldered Blackbird (*Agelaius phœniceus*), which does much harm and some good, as will appear later. Still another blackbird figures prominently in the rice fields; it is the large Boat-tailed Grakle (*Quiscalus major*), called "Jackdaw" by the planters.

The name of the "Rice-bird" is familiar to most persons in the North, but the magnitude of its depredations is hardly known outside of the narrow belt of rice fields along the coasts of a few of the Southern States. Innumerable hosts of these birds visit the rice fields at the time of planting in spring, devouring the seed-grain before the fields are flooded, and again at harvest-time in the fall, when, if the maturing grain is "in the milk," they feed upon it to a ruinous extent.

To prevent total destruction of the crop during the periods of bird invasion, thousands of men and boys, called "bird-minders," are em-

ployed, hundreds of thousands of pounds of gunpowder are burned, and millions of birds are killed. Still the number of birds invading the rice fields each year seems in no way diminished, and the aggregate annual loss they occasion is about $2,000,000.

The use of fire-arms has continued for more than a century, but has proved an expensive and inefficient remedy. Hence it is clear that some other means consistent with reasonable economy must be devised for the relief of the enormous losses now sustained by rice-growers from the depredations of birds.

Statistics showing the total quantity of rice annually produced in the United States are wanting, except for the year 1879-1880, when, according to the Tenth Census, the crop amounted to 110,131,373 pounds, worth, at 6 cents per pound, $6,607,882.38. In that year the product by States was as follows:

Rice produced in the United States in 1879-1880.

	Pounds.
Alabama	810,889
Florida	1,294,677
Georgia	25,369,687
Louisiana	23,188,311
Mississippi	1,718,951
North Carolina	5,609,191
South Carolina	52,077,515
Texas	62,152
	110,131,373

Value, at 6 cents per pound, $6,607,882.38.

Since 1880 the rice crop of Louisiana has more than doubled in quantity and value, but that of the other States has not increased in the same ratio.

As a rule the annual consumption of rice in the United States is almost double the production, as shown by the following table:

Table showing the quantities and values of the several kinds of rice imported, the total value, and the duty, each year, from 1880 *to* 1886 *inclusive.*

Years.	Dutiable.					
	Cleaned.		Uncleaned.		Paddy.	
	Pounds.	*Dollars.*	*Pounds.*	*Dollars.*	*Pounds.*	*Dollars.*
1880	46,314,785	1,212,508 53	359,668	9,316 48	249,066	4,707 00
1881	41,918,444	995,098 01	243,756	5,657 67	12,309	264 30
1882	63,253,521	1,417,467 84	618,633	9,994 32	2,651	45 00
1883	63,909,474	1,391,741 98	1,942,212	36,967 00	111,375	1,363 57
1884	64,098,827	1,378,263 71	9,158,943	174,149 00	8,112	146 00
1885	58,850,662	1,242,821 68	10,264,604	209,773 00	559,670	9,502 00
1886	43,497,923	870,262 93	5,294,005	110,722 50	144,330	3,536 00

Years.	Dutiable.	Free.		Total.	Total duties.
	Rice flour.*				
	Dollars.	*Pounds.*	*Dollars.*	*Dollars.*	*Dollars.*
1880	68,218 44	5,052,646	294,185 59	1,588,936 04	1,182,442 71
1881	67,190 74	6,986,306	389,016 80	1,457,227 52	1,069,329 07
1882	239,001 38	10,175,578	499,825 77	2,166,334 31	1,668,131 21
1883	463,335 24	12,926,951	610,323 60	2,503,731 39	1,753,907 30
1884	*517,851 77	12,398,433	558,476 00	2,628,886 48	1,683,365 94
1885	*672,092 06	8,291,360	404,477 50	2,538,666 24	1,619,576 25
1886	627,003 28	6,892,900	361,567 00	1,973,091 71	1,184,256 81

*Rice flour and meal.

In quality the imported rice is decidedly inferior to that grown in this country, and the price paid for it is correspondingly lower. The duty, however, is enormous, nearly equaling the cost. If, therefore, the bird plague can be abolished or reduced to comparative harmlessness, it is evident that great benefit will accrue both to the producer and the consumer; for, the home demand being greater than the home supply, the planter will profit by increased production and lessened expense; while the consumer will gain by securing a uniformly good quality of rice, of much higher nutritive value than the imported.

Among the numerous letters from rice-growers which have been received at the Department of Agriculture, asking for assistance in the attempt to secure some practicable remedy for the destructive ravages of birds, the following will serve to indicate the extent of the losses sustained in South Carolina, Georgia, and Louisiana.

Letter from Col. John Screven, of Savannah, Ga., President of the Georgia Rice-growers' Association.

In reply to your favor, requesting information concerning the depredations of the Bobolink or Rice-bird in the rice fields of my neighborhood, I furnish such information as I have with pleasure, hoping that it may assist in the discovery of some effective and economical means of arresting the ravages of this chief bird pest in the rice fields.

The Rice-bird is strictly migratory. It appears on the Savannah River commonly about the 10th or 15th of April, and remains, perhaps, until the 29th of May. During this incursion it is known as the "May-bird." It appears again about the 15th of August, when the early grain is hardened and is not so inviting to his appetite as when unripe and in the milk. The planter, observing these dates, seeks therefrom to seed the land and to have the young rice under what is known as the "stretch flow" before the spring flocks arrive, and to have the grain ripened before the autumn flocks return. If his planting is not finished before the spring flocks come, it will be delayed until late in May or early in June, when the birds have departed for the season. He looks to the ripening and harvesting of such late crops when the fall ravages of the Rice-bird have either ceased or are much diminished.

These data show how the destructiveness of the Rice-bird is in some measure avoided, and in part by taking advantage of the periodicity of its migrations; but despite the precautions so taken its invasions are ruinous to fields on which its flocks may settle, especially if the grain is in palatable condition and is on fields adjacent to marshes convenient for ambush or retreat. Bird-minders, armed with muskets and shot-guns, endeavor by discharges of blank cartridges to keep the birds alarmed and to drive them from the field. Small shot are also fired among them, and incredible numbers are killed; but all such efforts will not prevent great waste of grain, amounting to a loss of large portions of a field—sometimes, indeed, to its entire loss. The voracity of the birds seems so intense that fear is secondary to it, and they fly, when alarmed, from one portion of the field to another, very little out of gunshot, and immediately settle down again to their banquet.

As evidence of the numbers present of this bird and of the numbers killed in the rice-fields, a neighboring planter informs me that in 1884 he permitted four pot-hunters (contrary to the ordinary régime) to shoot in his fields, and in the course of the fall season they slaughtered and accounted for eight thousand Rice-birds. On every plantation large numbers are killed, and yet the visible supply of these robbers of the air does not seem in the least diminished. Every year the same numbers seem to swarm, and with wonderful prescience of the date of the coming harvest.

The Rice-bird comes only in seed-time and harvest to prey, so far as the rice fields are concerned, on crops raised at more cost and peril than any other known in agriculture.

The preventives now in use against its ravages have been already mentioned, but they are palliative only, applied at great expense, and without commensurate results. No vigilance on the part of the planter can do away with the wastefulness of powder and shot in the hands of careless and dishonest bird-minders. They only too often add the cost of wasted grain to the cost of their own faithless and ill-directed labor. In short, no effort yet tried, consistent with reasonable economy, will drive the Rice-birds from the fields or afford any well-founded promise of their reduction to harmless numbers.

Extracts from a letter from Capt. William Miles Hazzard, of Annandale, S. C., one of the largest rice-growers in the State.

The Bobolinks make their appearance here during the latter part of April. At that season their plumage is white and black, and they sing merrily when at rest. Their flight is always at night. In the evening there are none. In the morning their appearance is heralded by the popping of whips and firing of musketry by the bird-minders in their efforts to keep the birds from pulling up the young rice. This warfare is kept up incessantly until about the 25th of May, when they suddenly disappear at night. Their next appearance is in a dark-yellow plumage, as the Rice-bird. There is no song at this time, but instead a chirp, which means ruin to any rice found in milk. My plantation record will show that for the past ten years, except when prevented by stormy south or southwest winds, the Rice-birds have come punctually on the night of the 21st of August, apparently coming from seaward. All night their chirp can be heard passing over our summer homes on South Island, which island is situated six miles to the east of our rice plantations, in full view of the ocean. Curious to say, we have never seen this flight during the day. During the nights of August 21, 22, 23, and 24 millions of these birds make their appearance and settle in the rice fields. From the 21st of August to the 25th of September our every effort is to save the crop. Men, boys, and women are posted with guns and ammunition to every four or five acres, and shoot daily an average of about one quart of powder to the gun. This firing commences at first dawn of day and is kept up until sunset. After all this expense and trouble our loss of rice per acre seldom falls under five bushels, and if from any cause there is a check to the crop during its growth, which prevents the grain from being hard, but in milky condition, the destruction of such fields is complete, it not paying to cut and bring the rice out of the field. We have tried every plan to keep these pests off our crops at less expense and manual labor than we now incur, but have been unsuccessful. Our present mode is expensive, imperfect, and thoroughly unsatisfactory, yet it is the best we can do. I consider these birds as destructive to rice as the caterpillar is to cotton, with this difference, that these Rice-birds never fail to come. If the Government could devise some means to aid us in keeping off these birds it would render us great assistance. The loss by birds and the expense of minding them off in order to make anything renders the cultivation of rice a dangerous speculation. During the bird season we employ about one hundred bird-minders, who shoot from three to five kegs of powder daily, of twenty-five pounds each; add to this shot and caps, and you will have some idea what these birds cost one planter.

From Theo. S. Wilkinson, Myrtle-grove plantation, lower coast, Louisiana.

The rice crop in Louisiana, from the time the rice is in the milk till harvest time and during harvesting, is much damaged by birds, principally the Red-shouldered Blackbird. Shooting is the only remedy thus far resorted to which is at all effective, and it is only partially so. I have known rice crops to be destroyed to the extent of over 50 per cent., which is a loss of say $13 per acre. While this is an extreme case, a damage and expense of from $5 to $10 per acre is very common.

The average yield per acre is about 30 bushels, worth now (March 12, 1886) about 80 cents per bushel.

Early in the progress of the work a special circular to rice-growers was prepared (Circular 5, see p. 234), and copies were sent to all planters whose addresses the division was able to secure. The replies received were so startling in the magnitude of the losses they revealed, that it was thought advisable to make a thorough study of the whole subject of rice culture, and to investigate on the spot the manner in which the ravages were committed, in the hope of devising some means, compatible with reasonable economy, for lessening their extent. With this object in view the assistant ornithologist, Dr. A. K. Fisher, was sent on an extended tour through the rice-growing districts of the Southern States, from Charleston to New Orleans. His investigations were carried on in the spring, at and shortly after the time of planting. At harvest-time in the fall I visited the rice fields of portions of South Carolina and Georgia, and witnessed in person the destructive ravages of the birds at the height of the season. Furthermore, to render the investigation still more complete, the

Department has employed a special field agent, Col. Alexander Macbeth, whose headquarters are at Georgetown, S. C., in the very heart of one of the largest rice-growing districts. The results of all these investigations will be given in full in a forthcoming bulletin of the division.

THE DISTRIBUTION AND MIGRATION OF BIRDS.

The work of the Department on the Geographical Distribution and Migration of Birds is sufficiently outlined in the following circular, several thousand copies of which have been distributed by the division:

[Circular No. 8.]

CIRCULAR ON THE GEOGRAPHICAL DISTRIBUTION AND MIGRATION OF NORTH AMERICAN BIRDS FOR 1887.

Through the courtesy of the American Ornithologists' Union, the Department of Agriculture has secured the co-operation of this organization, and has undertaken to carry on the work begun by the Union on the migration and geographical distribution of North American birds.

The Department wishes to ascertain the whereabouts of all our birds during the winter season and the times of leaving their winter homes; to determine, if possible, the number and extent of the chief avenues of migration in North America, and the average rate of speed at which the different species travel; to find out the dates of their appearance at and disappearance from at least a thousand localities, both in spring and fall, for a period of years; and to map out the breeding areas of every species which rears its young in North America north of Mexico.

In order to obtain this information it is necessary to secure the voluntary services of a large corps of observers, each of whom is requested to contribute as full data as possible concerning the questions mentioned in this circular.

The first item in an observer's report should be a brief but careful description of the principal physical features, including latitude, longitude, and altitude, of the locality which is the seat of his observations.

The data collected may be arranged conveniently in three general classes: (*a*) ornithological phenomena; (*b*) meteorological phenomena; (*c*) contemporary and correlative phenomena.

(*a*) *Ornithological phenomena.*

Each observer is requested to prepare, at his earliest convenience, a complete list of the birds known to occur in the vicinity of his station, and to indicate (by the abbreviations inclosed in parentheses) to which of the following five categories each species pertains:

(1) Permanent residents, or those that are found regularly throughout the year (R).

(2) Winter visitors, or those that occur only during the winter season, passing north in the spring (WV).

(3) Transient visitants, or those that occur only during the migrations, in spring and fall (TV).

(4) Summer residents, or those that are known to breed, but which depart southward before winter (SR).

(5) Accidental visitants, or stragglers from remote districts (AV).

It is desirable also to indicate the relative abundance of the different species, the terms to be employed for this purpose being: Abundant, Common, Tolerably Common, Rare.

If you are in a position to observe the lines of flight of birds, have you noticed whether or not such lines are influenced by the topography of the country, and if so, to what extent?

If a mountain intercepts the line of flight, what kinds of birds pass around it, and what kinds pass over it?

What localities in your neighborhood are sought as resting-places by the various kinds of migrating birds? Can you give any reason for this selection?

What kinds of birds generally move in flocks, and what kinds in pairs or singly?

Are you familiar with any kinds of birds in which the males and females, and old and young, fly in separate flocks? In many species the males arrive in advance of the females, hence it is important to note the sex of the first comers, and the data at which the opposite sex is first seen.

Have you observed from year to year any increase or decrease in the numbers of any kind of bird known to you? If so, do you attribute such change to altered conditions in the bird's breeding-grounds? If not, can you assign a cause?

Have you observed the increase or decrease of one species to affect the numbers of another species? If so, can you explain the fact?

Has any kind disappeared altogether, and if so, can you assign a cause for this disappearance?

Among the birds which are now common about your station is there any kind that was formerly rare or absent? If so, can you explain the fact?

Among the birds which breed regularly in your vicinity have you ever observed an individual which by some personal peculiarity (such as the presence of white or dark feathers where they do not belong, or by some deformity) could readily be distinguished from others of its kind? If so, has this bird returned to the same place to nest year after year?

In recording arrivals and departures, it is highly important to distinguish between the movements of irregular stragglers of the advance guard or "van," and of the principal mass or "bulk" of the species. For this purpose observers are requested to note: (1) when the species is first seen; (2) when it is next seen; (3) when it becomes common; (4) when the bulk departs; (5) when the last individual is seen.

In addition to the above data, which *all* observers are requested to furnish, the Department particularly desires exact records of every increase and decrease in the numbers of a given species over a given area; for it is only by the knowledge of the daily fluctuations of the same species in the same place that the progress and movements of a "flight," or "bird-wave," can be traced. Such data can be contributed by experienced observers only, and in their procurement much time must be spent in the field. During the progress of the migratory movement the observer should go over the same ground day after day, and, if possible, both early in the morning and late in the afternoon. He should visit wood-lands, thickets of dense undergrowth, and open fields, and, if possible, both swamp and upland should fall under his daily scrutiny.

The above may be regarded as *essential data*. There are many other noteworthy details that bear more or less directly upon the complicated problems involved in the study of migration. Among such may be mentioned the bodily condition of the bird (whether fat or lean), the molt, and the period of song. The time of mating, when observed, should always be recorded.

The Department desires positive information concerning the food of all birds, and will furnish, on application, a special circular devoted to this branch of the inquiry.

(b) *Meteorological phenomena.*

Information is desired upon—

(1) The direction and force of the wind.

(2) The direction, character, and duration of storms.

(3) The general conditions of the atmosphere, including rainfall.

(4) The succession of marked warm and cold waves, including a record of all sudden changes of temperature.

(c) *Contemporary and correlative phenomena.*

The Department desires that the data under this head be as full and complete as possible, and requests exact information upon—

(1) The date at which the first toad is seen.

(2) The date at which the first frog is heard.

(3) The date at which the first tree-toad or "peeper" is heard.

(4) The dates at which certain mammals and reptiles enter upon and emerge from the state of hibernation.

(5) The dates at which various insects are first seen.

(6) The dates of the flowering of various plants.

(7) The dates of the leafing and falling of the leaves of various trees and shrubs.

(8) The dates of the breaking up and disappearance of ice in rivers and lakes in spring, and of the freezing over of the same in the fall.

It must not be supposed, because a large amount of information upon a variety of subjects is asked for, that meager or isolated records are not desired. Quite the contrary is true. Comparatively few of the observers are ornithologists, or even bird collectors—the great majority being intelligent farmers, tradesmen, and light-keepers. Those who know only the commonest birds, such as the Robin, Bluebird, Bobolink, Martin, Humming-bird, and Chimney Swift, can furnish important data, and their services are eagerly sought.

In order to secure better results, a portion of the territory under investigation has been divided into districts, each of which has been placed under the immediate direction of a competent superintendent. Observers not living within the limits of these several districts are requested to communicate with the Ornithologist of the Department of Agriculture.

The districts, with their respective superintendents, are:

New England.—Superintendent, John H. Sage, Portland, Conn.

Atlantic district.—New York (except Long Island), Pennsylvania, New Jersey, Delaware, Maryland, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Kentucky, and Tennessee. Superintendent, Dr. A. K. Fisher, Department of Agriculture, Washington, D. C.

Long Island, N. Y.—Superintendent, William Dutcher, 51 Liberty street, New York City.

Indiana and Southern Michigan.—Superintendent, B. W. Evermann, Terre Haute, Ind.

Ohio.—Superintendent, Dr. F. W. Langdon, 65 West Seventh street, Cincinnati, Ohio.

Light-house division of North America.—Superintendent, Dr. C. Hart Merriam, Department of Agriculture, Washington, D. C.

Light-house division of Spanish America.—Superintendent, L. S. Foster, 35 Pine street, New York City.

Schedules on which to record the more prominent facts relating to bird migration will be furnished on application.

The material collected in reply to this circular will be published in special bulletins.

Prof. W. W. Cooke, assisted by Mr. Otto Widmann and Prof. D. E. Lantz, has prepared a report on bird migration in the Mississippi Valley. This report, which I regard as the most important contribution yet made to the subject of bird migration, will appear as a special bulletin of the division.

Mr. L. Belding, of Stockton, Cal., has prepared a report on the ornithology of the Pacific coast region of the United States, with special reference to its economic aspects. This report will be issued as soon as practicable.

EFFECTS OF MAMMALS UPON AGRICULTURE.

The influence of small mammals upon agriculture, horticulture, and forestry is a matter of great practical interest, and one upon which much has been written, particularly in Europe, where a knowledge of the subject is a qualification of admission to the government position of forester.

Our native mammals affect the interests of mankind, directly or indirectly, in a variety of ways. Some are clearly beneficial; others are so markedly injurious, that the question becomes one merely of the best means of keeping them in check; while many kinds are both beneficial and injurious, and careful study of their habits is necessary to ascertain whether the sum of their beneficial qualities exceeds the sum of the prejudicial, or the contrary.

It is impossible to estimate in dollars and cents the damage done by the commoner species, particularly by Mice and Gophers, but in the aggregate it must amount to several millions of dollars per annum. From the Atlantic to the Pacific and from the Mexican border to Canada innumerable hordes of Mice are constantly preying upon the results of man's toil. They gnaw his buildings, deplete his granaries, make their homes in his barns and hay-mows, and even infest his private dwellings to share the dainties of the pantry. In the meadow and pasture they feed upon the roots of the best grasses; in the garden, upon the roots, fruit, and seed of vegetables; and in the fields, upon grain, both standing and in the shock. In winter they

destroy fruit and forest trees and ornamental shrubs by eating the bark from the roots and trunk. The number of Meadow Mice present over a given area is subject to periodical fluctuations, and they sometimes become enormously abundant. At such times their runways through the meadows and grain fields result in the loss of at least one-fifth of the crop.

The depredations of Ground Squirrels and Gophers in the prairie regions of the Mississippi Valley and in the far West are well known, and yet the extent of the damage they do is not generally recognized. In a fertile part of the Sacramento Valley in California a few years ago the sudden increase in a species of Ground Squirrel which fed upon grain caused the land to depreciate one-half in value. To be more explicit, land which previously brought \$100 per acre could not be sold for \$50, and the depreciation was due solely to the abundance and ravages of the Squirrels.

Special attention has been given the animals which occasionally or habitually prey upon poultry, and the results will be made public at as early a day as practicable.

RABBITS.

The Australian Rabbit.—There has been of late a good deal of newspaper talk about the expected introduction into the United States of a large colony of so-called "Australian Rabbits," and various opinions have been expressed as to the probable effect of such an importation upon our agricultural industries. Hence a few facts concerning this Rabbit may prove of interest.

At the outset it should be stated that, correctly speaking, there is no "Australian Rabbit," no species being indigenous to Australia. The Rabbit which has done so much harm in that country and in New Zealand is an introduced species, namely, the common Rabbit of Europe (*Lepus cuniculus*).

A very good idea of the magnitude of the rabbit pest in Australia may be had from perusal of the following report of Consul-General Morgan, of Melbourne, Victoria:

Tame Rabbits were brought to these colonies in very early years, but the common gray variety of wild rabbit, that has so overrun the country, was, so far as can be authoritatively ascertained, introduced by a large landed proprietor in the western district of Victoria about the year 1860 for the purpose of sport. From the western district they spread to the stony rises between Colac and Camperdown, in which place the splendid cover afforded them caused their rapid increase, and they multiplied with such astounding rapidity as to literally overrun all that portion of country.

Some years after they were taken to other parts of the colony. The pest soon after this was found in the neighborhood of Horsham, spreading thence into the Mallee country, extending northeast to Swan Hill.

The country west and north of Horsham being exceedingly favorable to them, consisting of sand hills, pine ridges, and scrub, they increased there greatly, and have done serious damage to crops during the past few years, principally since 1874.

So great has been their fecundity, that there are now but few places in Victoria in which they do not exist—from Point Nepean along the coast, from Queenscliff to Geelong; in Gisborne, Ballan, Bacchus Marsh; away northwest to Nhill and north to Swan Hill; along the Murray River; on the New South Wales and the South Australian borders—Gippsland and the surrounding district being the only place in which they are conspicuous by their absence. In the rangy district of Mansfield they have made an appearance, and the Buffalo, Howqua, King, and other rivers in the neighborhood of Bright and Myrtleford, are now invaded by the pests in large numbers. It is, however, noticeable that in places where the soil is hard, or the climate cold or wet, the rabbit does not increase to anything like the extent observable in country more suited to them, such as sand hills, pine ridges, &c. There is also another peculiarity observed, which will be borne out by all who have had any great

experience on this subject, viz, that where hares increase and become numerous the rabbits do not. There may be an exception to this, such as on the Werribee estate, but nevertheless it is the rule.

LOSSES SUSTAINED.

It is doubtful whether many persons are aware of the immense loss that has been sustained in this colony through the ravages of the rabbits, but it is an undoubted fact that as much as £23,000 has been expended to clear one estate and keep the pests under, and in many others it has cost the owners large sums, from £15,000 downwards.

In addition to the expense incurred by private owners, shire councils, and the government in destroying the pests, the great depreciation in the value of land and its grazing capabilities has to be considered. For instance, the stony rises, consisting of about 20,000 acres and surrounded by some of the finest grass-land in Victoria, have been rendered of little value except for rabbits, the owners of the land obtaining a small rental from trappers; and about 4,000 acres were some while back disposed of at the low figure of 10 shillings per acre. In the discussions in the colonial parliament on the introduction of the late "Malle pastoral leases act," it was clearly pointed out that the country (12,000,000 acres) affected by the bill had been rendered almost useless and uninhabitable through the damage caused by the ruthless invader. Stations on which smiling homesteads, fine orchards, and other improvements had a few years back existed were fallen into ruin and deserted by all living creatures except the rabbits. Here, where the grass and salt-bush in 1875 were sufficient for nearly 700,000 sheep, enough did not grow in 1882 for one-seventh of that number, the loss during the past five years being estimated as at least three-quarters of a million sterling, besides £40,000 decrease to government in rents and £20,000 expended in destroying the pests. To illustrate the damage here, I cannot do better than attach the particulars given of a few stations in the above discussion.

Year 1877, Bruin Station carried 36,000 sheep, rental £500; in 1879, 10,000; run abandoned; relet under grazing license for £56. Wanga and Nipo, once carrying 20,000 sheep; rental £400; now not a sheep on the run, which was also abandoned and relet for £20. Lake Hindmarsh carried, in 1877, 33,000 sheep; lost 25,000 in two years; rent £700, now £72. Corong, 1877, 36,000 sheep, now 3,000; rent £1,050, now £150; and several others were mentioned as being in an equally bad position.

In the years 1875 and 1876 the production of wool in the Mallee country was about 5,000 bales, value £100,000. In 1882 this had fallen to 900 bales, worth, say, £18,000. Eighteen runs in this district in the year 1878 yielded 1,700 bales; in 1882 only 332 bales. The runs were all abandoned, and the land held from government under grazing leases, at an almost nominal rent, by persons that trusted that something would be done to improve the tenure under which the land could be held, and give them an opportunity and sufficient inducement to endeavor by combined action to destroy the rabbit pest, and render the land once more fit for profitable occupation.

Whether the lengthened tenure now given to this part of the colony will enable the desired result to be achieved remains to be seen.

REMEDIAL MEASURES.

During the past three years the government has expended about £30,000 in Victoria on the extirpation of the rabbit, the principal means used being poison, such as phosphorized oats and wheat, arsenic mixed with bran and chaff, and bisulphide of carbon.

The various shire councils in the badly infested districts have also adopted similar means, though in the majority of cases the rabbit act has not been strictly enforced, many of the shires not being in a position to incur the extra expense necessary to do so.

In addition to the means above mentioned, the councils have arranged for the purchase of rabbit-skins or ears and scalps, and have been assisted by the government to the extent of a bonus of 3*d.* per dozen on all skins or ears and scalps purchased by them. From various reports published at various times in the papers, and inquiries made, the number of rabbits destroyed has been considerable, at least 157,000 dozen, equal to 1,884,000 scalps and ears and skins, being paid for in less than two years; the St. Armand and Swan Hill shires being the largest purchasers.

In the Colac and Camperdown district a preserving factory was started some few years back, and operations carried on with vigor, the factory working each year for about six months, from March to October, and during that period purchasing from 750,000 to 1,000,000 rabbits, the price paid being about 2*s.* 6*d.* per dozen. These rabbits are nearly all obtained from the stony rises and surrounding districts, as they cannot be sent to the factory in proper condition from any great distance.

The sum voted this year by parliament for rabbit extirpation is £10,000, and I learn from the Sydney papers that in New South Wales no less than £74,000 has been voted for the same work and in South Australia the amount is £30,000; so that it will be seen that Victoria is by no means the greatest sufferer, more especially as she is at the expense of labor and material on crown lands in pastoral occupation as well as crown lands unoccupied.

The number of skins exported from Victoria during 1883, as near as can be ascertained, was 4,000,000, and the area of land more or less infested is about 20,000,000 acres.

Having given the above sketch anent the introduction, spread of, and damage done by the rabbits, I will now give a few particulars respecting their fecundity and the methods and means employed to destroy them.

In places where the pest is numerous they can be considerably reduced by trapping, hunting with dogs, and shooting; but these methods are expensive, slow, and will never more than thin them out, leaving plenty to multiply again. It can be asserted on good grounds that one pair of rabbits will, under most favorable circumstances, increase in two and a half years to the enormous number of 2,000,000; this is assuming the district suits them. But, allowing that they only increase to one-fourth that number, it may be easily seen how necessary it is to be continually on the watch to destroy them.

Phosphorized oats are much superior to trapping in results, and less expensive; but unfortunately experience proves that they will not always eat this grain, and when grass is at all plentiful the rabbit deems it a much greater delicacy. Singular to say, phosphorized oats are not found effective in all parts, instances being well known in which that poison has been greedily devoured in one district, whilst at the same time in an adjoining one nothing would induce the pests to touch it—bran, chaff, and arsenic being preferred. Neither of the latter mixtures can, however, be used with any effect in wet or damp weather.

Arsenic and carrots, or phosphorized wheat, have also been found effective when the other poisons mentioned fail.

I am informed by the Hon. A. Morrach, secretary for lands, that there are about 500 miles of rabbit-proof wire-net fencing erected in this colony of Victoria, at an average cost of £80 per mile.

The estimated damage by rabbits would be difficult to ascertain, but it may be safely stated that during the last ten years the loss caused by the pest through decrease in carrying capabilities of land, destruction to crops, loss of rents, &c., would amount to at least £3,000,000 sterling.

JAMES M. MORGAN,
*Consul-General.**

UNITED STATES CONSULATE-GENERAL,
Melbourne, October 5, 1886.

In New Zealand the legislature took the matter in hand in 1876 and began the enactment of a series of stringent laws for the suppression of the rabbit scourge.

Owners and occupiers of land are compelled, under a penalty, to take efficient steps to clear their property of rabbits on receiving notice to that effect from the inspector of their district; and continued neglect of such notice gives the inspector a right to take whatever steps he may deem necessary for the destruction of the rabbits, and to recover the cost summarily from the defaulting owner, in addition to the penalty. The statute, moreover, exempts from taxation all dogs certified to by an inspector as kept solely for the purpose of destroying rabbits; and imposes a penalty for the destruction or capture of ferrets, weasels, or such other animals as may be officially proclaimed to be the natural enemies of the rabbit.

In 1881 more than 500,000 acres of sheep runs were abandoned on account of the rabbits, and the loss to the exports of the colony was calculated to be $2,500,000 per annum; and it was estimated that upwards of 180,000,000 rabbits were killed in New Zealand in little over three years.

Many cases might be cited, prominent among which is that of the English Sparrow, to show that the transplanting of a naturally prolific species to a country where the conditions for its existence are

*U. S. Consular Reports for December, 1886, Vol. XX, No. 72, pp. 482-484.

favorable gives it a peculiar impetus and enables it to crowd out and supersede the indigenous related species. Hence, while there is no positive evidence to show that the European Rabbit would become the curse in this country that it is in Australia and New Zealand, yet there is no proof to the contrary, and its introduction here would be, to say the least, an unnecessary and hazardous experiment.

The Rabbits of the United States.—We certainly have enough rabbits of our own—at least a dozen native species—and the injury they inflict upon our agricultural industries is by no means insignificant. In the grape growing districts of California rabbits do so much damage by gnawing the vines that in many cases it has been found necessary to inclose the entire vineyard with rabbit-proof wire netting, the cost of which is very great.

In the San Francisco (Cal.) *Weekly Bulletin* of February 16, 1887, it is stated that for a number of years Messrs. Grimsley and Miner have been in the habit of poisoning Jack Rabbits "by thousands" on their places near Tulè River, thus averting the loss of thousands of dollars. Mr. Miner estimates the number of rabbits he has killed in this way "at not less than twenty thousand, and he thinks that during this season not less than two thousand dozens have been killed by dogs and hunters along the river, many of which have been shipped to game dealers in San Francisco. From this statement, which is fully sustained by others, some idea of the magnitude of the evil can be formed. Mr. Dewey, near Tulare, has had a hunter in the early part of the season who killed usually four or five dozen a day and shipped them to the city. He says he has twenty acres of young alfalfa of last year's sowing, the growth of which the rabbits got away with almost entirely during the winter months, causing a loss during the whole season of not less than $500."

Mr. Willson G. Nowers, of Beaver City, Utah, writes to the Department, under date of February 1, 1887, as follows:

In regard to mammals, the most common, and by far the most destructive, is the hare, or, as it is usually denominated, rabbit. At times its ravages are enormous, as it sweeps down from the bench-lands and sage-plains in myriads, devouring entire fields of cereals. This was the case last year in this and adjoining counties, where its depredations amounted to several thousand dollars, and some farmers in this county lost from this source alone their entire crop of small grain. At Minersville, this county, not more than one-third of the crop was harvested. At Adamsville nearly the total crop was taken; at Greenville about one-half, and here (at Beaver) about the same proportion; and the crops in Iron County, on the south of us, were damaged to about the same extent.

Our mode of destroying these pests is to select two captains, who choose their associates from the community, and form two attacking parties, and raid the country with fire-arms, clubs, and dogs, killing every rabbit caught sight of. In some cases the slaughter has amounted to nearly one thousand by each side. These raids are made on every favorable opportunity, after a snow-storm, if possible, or monthly if no snow falls.

About nine years ago the country was overrun by these rabbits, but after two or three seasons' ravages they became so scarce that hardly a representative was to be seen. They were infested with large grubs in the head, resembling those sometimes found in the backs of cattle. These grubs invariably put an end to their victims. If this enemy had not attacked the rabbits it is probable that the latter would have produced a dearth in the land.

E. C. S. Foster, M. D., of Russell, Kansas, writes:

Rabbits are very destructive to fruit trees; they eat off the bark during the winter months, The damage done is serious.

Mr. W. Head, of Bristow, Iowa, writes:

Rabbits are injurious to fruit trees. During the winter they gnaw the bark, very often completely girdling an apple tree, which of course kills it. I consider the loss serious, as I have seen a great many apple trees killed in this way.

Mr. William J. Howerton, of Florence, Ariz., writes:

The little cotton-tail rabbit of this country occasions some damage by barking the young growth, but the damage is of comparatively little consequence and is chiefly done in the winter months.

Mr. John S. Harris, of La Crescent, Minn., writes:

Hares often do serious damage to trees and shrubs. Some seasons acres of young forest trees are barked by them. Maple and apple trees suffer most from their depredations.

Mr. J. W. Johnson, of Meriwether, S. C., writes:

Gardens are sometimes injured to a great extent by rabbits. They are particularly fond of young cabbage, collard, and pea-plants; they also gnaw the stalks of cabbage and collards in the winter. They are more injurious if the winter is severe than when the weather is mild. They are very injurious to fruit trees in the winter; they gnaw the bark from the ground up, as far as they can reach. Unless the trees are protected they will often ruin a whole orchard of apple trees.

Mr. J. C. Linville, secretary of the Agricultural and Horticultural Society of Gap, Pa., writes:

Rabbits are very destructive during deep snows. They gnaw off the bark above the snow line, and cut off small trees as thick as a lead pencil. They seldom girdle peach or cherry trees, unless apple trees are not at hand. The loss is very great.

Mr. Thomas Mikesell, of Wauseon, Ohio, writes:

Rabbits peel small apple trees and also eat off the twigs. They peel other trees and shrubs, the elder in particular. The damage is sometimes very serious.

Mrs. A. L. Peabody, of Denver, Colo., writes:

In the vicinity of Grand Junction the rabbits have injured young fruit trees to quite an extent. It was done during the winter.

Mr. F. M. Powers, of Angola, Ind., writes:

Rabbits are destructive to vines and to small fruits, such as raspberries. They injure young fruit trees by girdling and eating the bark.

Mr. William H. Madison, of East Enterprise, Ind., writes:

Rabbits destroy many young trees, especially apple trees, by gnawing the bark and thus girdling them. This is done in the winter when snow is on the ground. They do some damage to corn in the field, but not to a serious extent.

Mr. E. L. Reynolds, of Westville, Ind., writes.

The gray rabbits make their home along the hedges, in thickets, and in the timber; they increase rapidly and are the pests of young fruit trees. They are very plentiful in this part of the State, but their numbers are kept within bounds by the hunters.

Mr. N. W. Wright, of Farmland, Ind., writes:

Rabbits gnaw the bark from apple and pear trees in the fall and winter. The damage has been serious in many instances.

Mr. E. S. Beach, of Valparaiso, Ind., writes:

Rabbits injure trees in the winter, when there is a heavy fall of snow on the ground; loss sometimes quite serious.

Mr. J. C. Donaldson, of Gilbertsville, N. Y., writes:

Rabbits are injurious to grain crops, both by consuming the grain and by trampling it down.

Mr. F. Eveland, of Ferry, Iowa, writes:

Rabbits are injurious to trees. They are most destructive in winter.

Mr. George R. Prescott, of Galt, Canada, writes:

Rabbits do some injury to vegetables, but not to a serious extent.

Mr. R. Elliott, of Plover Mills, Canada, writes:

Rabbits eat herbage, chiefly clover. They girdle and bark all sorts of young trees during the winter.

Mr. L. W. Suilot, of Salem, Ohio, writes:

Rabbits eat apples and the leaves of the Swedish turnips; loss trifling.

Mr. I. H. Shank, of Hickory, W. Va., writes:

Rabbits sometimes eat fallen apples, but the loss is trifling. They gnaw the trunks of young apple trees, thus killing quite a number.

Mr. William West, of Chehalis, Wash. Ter., writes:

Rabbits occasionally injure apple trees by eating the bark during the winter, but the loss is trifling.

Mr. J. C. Cavener, of Gainesville, Tex., writes:

Rabbits are very destructive to English peas; they like cabbage also. They are liable to damage nearly all kinds of fruit trees, and all soft-rooted forest and shade trees, by gnawing their roots in two. They girdle or gnaw the bark from the collar of young peach, apple, pear, and plum; and sometimes Bois d' arc hedges are damaged by them. They are worse when the ground is frozen or covered with snow.

Mr. H. W. Buckman, of Glenwood, Cal., writes:

Rabbits eat squashes melons, and cucumbers, both the young plant and the fruit.

Mr. David H. Herman, of Willows, Dak., writes:

Hares and rabbits gnaw young fruit trees in winter.

Mr. W. R. McDaniel, of Faceville, Ga., writes:

Rabbits eat garden peas. The loss is serious.

THE IMPORTATION OF EXOTIC SPECIES SHOULD BE GOVERNED BY LAW.

The great calamity that has befallen our agricultural industries in the importation of the English Sparrow, and the threatened danger from the introduction of the European Rabbit, should serve as timely warnings to an intelligent people and lead to legislation restricting the importation of foreign birds and mammals.

It seems desirable that a law be enacted conferring upon the Commissioner of Agriculture the power of granting or withholding permits for the importation of birds and mammals, except in the case of domesticated species, certain song and cage birds (to be specifically enumerated), and species intended for exhibition in zoological gardens, menageries, and museums, which may be brought in without special permits.

The question of the desirability of importing species of known beneficial qualities in other lands is one which sooner or later must force itself upon our notice; and it is highly important that when such experiments are made they should be conducted by or under the control of the Department of Agriculture. And it may be suggested that isolated areas, such as islands of suitable size and character, be selected for this purpose, so that the spread of the species may be prevented if the result renders this course desirable.

WASHINGTON, D. C., *February* 20, 1886.

C. HART MERRIAM,
Chief of Division of Ornithology and Mammalogy.

Hon. NORMAN J. COLMAN,
Commissioner.

REPORT OF THE POMOLOGIST.

SIR: I have the honor to hereby present the report of the Division of Pomology, giving a synopsis of its work from its establishment until the present time. The act of Congress which created it took effect on July 1, 1886, and my appointment as chief dates from that day. As this work is new and untried, so far as the Department is concerned, except that which Mr. William Saunders, Superintendent of the Gardens and Grounds, has done voluntarily, and without the aid of an appropriation, there has been no precedent to follow or established line of action to which I might conform my labors. I cannot say less than that I feel highly honored in having been chosen to conduct this work, and its responsibilities are deeply felt by me. The fruit-growing industry of the United States, from all that we can gather by the crude and inefficient means at hand, amounts to between two and three hundred millions of dollars annually. It is estimated by several careful observers that there is at least as much more in value lost by insect depredations, by mistakes made in planting unsuitable varieties, and in ignorantly caring for the fruit-bearing trees, vines, and plants of the United States, a great share of which might be saved by our people with comparatively little outlay of means and labor if intelligently applied. To gather such information and distribute it is certainly within the legitimate province of this division, and is one of the main points towards which we hope to make progress. It is with pleasure that I have begun this work, which accords so well with my feelings and my chosen life-work, because I find the pomologists and horticulturists all over the country bidding me good cheer. Very many of the leading fruit-growers and life-long experimenters in practical pomology, as well as those of a more scientific turn, have given me much encouragement by offering their grounds and personal labors to help on the work.

The heads of the experimental departments of all the agricultural colleges visited or corresponded with, have been equally favorable and generous. The various rural papers of the country have also offered their services.

Considerable work has been done in the way of gathering specimens of fruits and making drawings and accurate descriptions of the same for future use by the Department. Many orchards, vineyards, and experimental grounds have been visited, and information gathered by myself from personal observation.

THE FUTURE OF THE DIVISION.

Now that the division has been established, it is hoped that something of permanent value for the fruit-growers of the entire country may be done, although the present appropriation will not permit the consummation or even the introduction of plans that must be carried into effect if the division shall fully serve the purpose for which it was instituted.

A system for the collection of statistics should be inaugurated by which might be learned the real facts as to the magnitude of our pomological industry—its progress and its possibilities. The production and consumption by our people of fruits, both fresh and preserved, is in value and extent scarcely less than that of the cereals; and it seems proper that similar attention be given to the collection and dissemination of information concerning fruits.

EXPORTS VERSUS IMPORTS.

The United States contains some of the largest and best-adapted fruit-producing regions of the world, and foreign markets should be investigated, with a view to the benefit of the home producer. This is especially applicable to that best of all fruits, the apple. And now that the evaporation of fruit has become so successful, it is highly important that we avail ourselves of every means to increase our exports of fruit products. Already a considerable advance has been made in the production of citrus fruits, and as this branch of our pomological industry is only in its infancy, it is hoped that we may in time be able in a great measure to avoid the necessity of importing these fruits. There are also many other fruits, such as the guava, olive, pineapple, and cocoa-nut, which need the special attention of our Government to encourage and advance their culture.

COLLECTION AND DISTRIBUTION OF VARIETIES.

Many of our choicest fruits have been found in obscure parts of this country and some in foreign countries, and no doubt there are others of equal or better qualities that remain unknown to our people because of the lack of proper investigations. All such fruits should be sought out and at once placed in the hands of the people for trial, and this work can be successfully done by this division, provided means are allowed. This would add considerably to work of this kind now being performed in a limited way by the Department and add greatly to its usefulness.

SUMMARY OF INVESTIGATIONS.

In accordance with your orders, on the 6th day of August, 1886, I proceeded from my home at Geneva, Kans., to attend the meeting of the Central Texas Horticultural Society at Fort Worth, and to visit such other places as I thought best in that State in making pomological investigations. I there found assembled a goodly number of the workers and thinkers who are interested chiefly in pomology. Although this was just at the close of a drought of exceptional severity in that State, there were shown upon the exhibition tables many fine specimens of luscious peaches, pears, plums, grapes, and berries. From the statements made by those present I learned that in Texas peaches can be eaten fresh from the tree from May to December if care is given in the selection of varieties. Indeed, the peach is one of the most popular fruits grown in that State, as it nearly always bears a good crop, and the fruit is of the very highest quality. The choicest variety grown, and the one that brings the highest price in market, is the Chinese Cling. It is very

large, of a creamy white color, often slightly blushed, and of a very sweet and delicate flavor. Of grapes there was a very fine exhibit. Judging from the specimens upon the table, from what was testified in the meeting, and from what I saw in vineyards visited in several parts of the State, it is safe to say that nearly all varieties of native American grapes and some foreign varieties do remarkably well. Rot and mildew are prevalent to some extent, but not to such a damaging degree as in many other States. This is owing to the drier condition of the atmosphere. In several vineyards the Triumph, which is a variety that usually succeeds poorly in the North, was seen bearing very large clusters in abundance. Here the Herbemont, which is too tender for the Northern States, seems to be at home. Among the plums, Kelsey's Japan is perhaps now attracting more attention in Texas than any other variety. It has been planted there in a limited way since 1885, but in only one or two cases has fruit been noticed; indeed, it could not be expected on trees so young, although it is an early bearer. In some cases, towards the northern line of the State, the trees were reported tender. Special notes upon this fruit will be found in another part of this report.

Prunus Simonii is another new variety that was well reported by all who had experience with it. I saw it growing in several portions of Texas, and for that matter in many other States, and in all cases it has proven a hardy and a thrifty grower. However, its very recent introduction has prevented the bearing of fruit so far, except in a very few cases. Perhaps the best information that can be given is to quote the words of Prof. T. V. Munson, of Denison, Tex., on whose grounds I saw the largest trees:

> It fruited with me in 1885 for the first time, probably the first in the United States. The fruit when ripening shines like apples of gold, becoming a rich vermilion when fully ripe. It ripens shortly after Wild Goose, and showed no defects from attacks of curculio or rot, which were very abundant in 1885 and destroyed all my blue plums. It is very firm and meaty, equal to any blue plum I have ever eaten, and will carry any desired distance. Tree very thrifty, upright; early and an abundant bearer; hardy in Iowa, and endures Texas drought to perfection.

The Blackman Plum, which has been very generally planted for several years, has not, in any case reported, been known to bear fruit, although it has often bloomed. It is now quite well proven that it is a hybrid between the peach and plum, and, like many hybrids, is sterile As a fruit-bearing tree it is a failure, and should not be planted by any one.

The Japan Persimmon, where it is hardy, seems to be steadily winning its way into the favor of planters. The trees are often tender when young, but when several years old will stand rather more cold than figs. In the southern part of Indian Territory I saw a tree some ten feet high which the owner told me had the year before borne about a bushel of fruit, and which then had on it several large specimens. The Japan Persimmon is unlike our native species in that its flowers are perfect—that is, have both stamens and pistils in one flower—while ours has the two sexes on different trees. Apples seem to do moderately well in a great many places in the northern part of the State, but late keepers are very scarce. The Ben Davis seems to be one of the best for that section. As the center of the State is approached the climate becomes too warm, and apple culture has to be abandoned. Dallas is the name of a new blackberry that originated near the city of that name, and is grown quite largely and very successfully in that locality.

The Olive is growing at Mr. Nat. Stephens's place, at Forney, Kaufman County, and so far with every prospect of success. I had the pleasure of seeing the Post Oak Grape, or, as it is scientifically known, *Vitis Lincicumii*, growing and bearing in its native habitat. By many this species is confounded with *V. æstivalis*, but it is now generally conceded to be distinct. It is found growing in the same localities and soils as the Post Oak, and hence its name. It is confined to high and often rocky lands, but develops the finest fruit along little ravines near small rivulets. It is never, or very rarely, seen in the low bottom-lands. Its roots are very deep, and a severe drought has little effect on its growth. The territory in which it is found comprises Northeastern Texas, Eastern Indian Territory, Western Arkansas, Southwestern Missouri, and a small portion of Southeastern Kansas. On the higher lands of this region it spreads its thrifty branches and runs over low bushes, and is sometimes found climbing to the tops of trees. This latter, however, is rather rare, as its growth is generally low. It is often seen growing in open forests where there is grass enough to feed the annual fires, and these frequently kill the vines to the ground, but their hardy nature enables them to survive and throw out numerous sprouts from the base, much like a stool of the Black-cap Raspberry The fruit varies in color from deep black to pale red, and even green. Sometimes the clusters are very long and loose, and others are as compact as the Elvira. The berries also vary in size and shape, but are usually about like the Clinton. Their taste is often rather sour and astringent, but occasionally a variety is found of mild and delicate flavor. Some that I gathered were about equal to the Concord, and many of them better than the Clinton. One very promising feature of their flavor is the entire freedom from the foxiness that is so objectionable in all the varieties of *V. labrusca*. The season of ripening of the different varieties is so varied, that at least six weeks elapse between the earliest and latest.

Strange as it may seem, it is true that until within the last few years no one of the great army of horticultural experimenters has attempted to cultivate or improve the varieties of this species, and it seems the more particularly strange when we consider that of all the known species of the *Vitis* family this is the most productive of wild varieties of high quality. To this any one who knows our native grapes and has traveled through the forests within the territory named will bear me witness. But now we have a gentleman of the most eminent ability, both scientific and practical, in the person of Prof. T. V. Munson, who has taken the matter in hand. He has not only transplanted to his vineyards vines of the best wild varieties he could find, but he has with wondrous care cross-fertilized these with some of our finest cultivated varieties, and has grown seedlings from this fruit I might say that Professor Munson is raising a new race of grapes, and with the most promising results already. He has several seedlings of excellent quality, and has hundreds more that are yet too young to fruit. We certainly have much to expect from this race, and especially when it is in such good hands. It is really worth a trip to Texas to see Mr. Munson's rows of young seedlings and to enjoy the benefit of his intelligent explanations. We are quite likely to gain from this species and its crosses much in the way of a hardy constitution of vine, giving it ability to withstand both drought and cold. Norton's Virginia is the nearest approach to this class of grapes it being a pure *V. æstivalis*. Mr Hermann Jaerger, of Missouri, has also been experimenting with varieties and crosses of *Vitis Linci*

cumii for some few years. He has grown a few varieties from cross-fertilized seed that produce fruit of good character. These two pomological experimenters are working each with an understanding of what the other is doing, and it is to be expected that something good will result.

Soon after my return to my home near Geneva, Kans., that being my headquarters at that time, I was directed to attend the meeting of the American Horticultural Society at Cleveland, Ohio, and to visit such other places in Ohio and Michigan as might be desirable in my pomological investigations.

In compliance therewith, on the 3d day of September I started for Ohio, and after spending several days at the old home of our beloved and lamented Dr. John A. Warder, examining his orchards and pomological notes, I arrived at Cleveland, where the meeting was held. As the proceedings of that meeting have been quite generally published in the papers of the country, and a full report is in process of publication by the secretary, W. H. Ragan, of Greencastle, Ind., it is not deemed desirable to give more than a few of the principal points of interest.

Mr. J. M. Smith, of Green Bay, Wis., read a paper showing the efficiency of drainage and thorough cultivation as a remedy for drought. He is one of the most successful growers of strawberries and other small fruits in the United States, and during the drought of the past summer, which was one of the severest ever known, by the application of these two principles his plants retained their vigor and bore heavily. Too much stress cannot be laid upon these two points in practical pomology. Underdraining not only carries off a surplus of water, but retains the soil in a comparatively uniform state as regards moisture; and every thoughtful farmer knows that frequent stirring tends to the same end. In other words either, or better yet both, of these methods together make a dry soil moister and a wet soil drier.

In the discussion of the strawberries it was clearly seen that the Crescent had the greater share of praise as a practical market and family berry nearly all over the United States and Canada. In the South, Neunan is one of the leading kinds. Among the newer ones, Jessie is perhaps the most promising. It is a seedling, originated by Mr. F. W. Loudon, of Janesville, Wis. The Jewell was also well spoken of by nearly all who had tried it.

Among blackberries the Snyder seemed to be as well spoken of as any, its extreme hardiness (for the colder Western and Northwestern States especially), productiveness, and good quality offsetting its small size. Kittatinny holds a good place yet in public esteem. Among the newer kinds, Minnewaska, from Mr. A. J. Caywood, of New York, is likely to receive favorable notice. It is large and very robust in growth, even more so than Kittatinny, and much the same in fruit. Lucretia Dewberry is very early, large size, and productive, but it is said to be very difficult to pick because of its trailing habit and ugly prickles. It is also not of first quality when compared with good blackberries.

In the face of all the discouragements from Mildew and Black-Rot, the grape elicited much discussion. Leaving all the older sorts, because of their generally well-known characters, both good and bad, I will mention a few of the newer ones. Niagara and Empire State seem to be making a rather even race for the leadership among white grapes. Indeed, they seem, from what I have heard others say and

from what I have seen and know from observation, to be an advance upon the varieties heretofore grown. Worden is likely to supplant the Concord, as it is several days earlier, a little larger and better in quality, and in all other respects fully equal to that old standard variety. Ulster is a red grape of high quality, vigorous in vine, and a remarkable keeper. Poughkeepsie is also a red grape, the product of a cross between Iona and Delaware, and of fine flavor. It is, however, a little below medium size, and is not a strong grower. These last two seedlings were originated by Mr. A. J. Caywood, of Marlborough, N. Y.

The two pears that seemed to engage the special attention of the members were Keifer and Le Conte. Specimens upon the tables showed both these varieties to be large and handsome, and although their flavor was not equal to such standards as Sheldon and Bartlett, yet they were passably good. Those grown in the Southern States have much less of that peculiar and unpleasant astringency so common to the Chinese Sand Pears than is found in those from the north. In the exhibit from North Carolina were many fine specimens of the Le Conte that would challenge the admiration of any one. The discussions elicited the fact that neither of these is exempt from blight, as some have claimed.

Apples were of course shown in profusion, though there were no new varieties of peculiar interest. It was a surprise to a great many to see such fine displays of apples from the South as were shown by Mississippi and North Carolina. It has been usually thought that in Mississippi especially, apples could not be grown profitably, but this is certainly a mistake. Perhaps in a commercial sense it may be true, but for home use they can and should be grown. The higher lands of Western North Carolina and Virginia are especially well adapted to apple culture. There they may be grown commercially quite as well as anywhere in the United States. The Yellow Newtown, which is a precarious bearer in very many sections, does remarkably well on these elevated lands.

After the meeting had closed I had the pleasure of visiting the famous vineyards about Euclid, some 10 miles east of the city of Cleveland. No locality surpasses this for the production of Catawba grapes. The vineyards are planted principally on the slopes facing Lake Erie, but many are on the plateau between the foot of the hills and the beach, and on the table-lands above and back of the steeper slopes. From the summit of the hill above the village of Euclid could be seen fully three thousand acres of vineyards. The greater part of these vineyards are set to Catawba, Concord, and Delaware. The Niagara is growing here, and I examined one vineyard in its third year that was heavily loaded with fruit. The clusters were large and well formed, and impressed me fully as well as a vineyard of the same variety that I had seen near Fort Worth, Tex. This is perhaps the best variety of white grapes to plant for the States east of the Rocky Mountains, unless it be the Empire State.

The Michigan State fair, held at Jackson, was next visited. A large and very fine display of fruit was exhibited. The apple can be seen in its glory in this State, but the show of plums was particularly fine. They were mostly from the northwestern counties of the southern peninsula. Many of them were equal in size to those grown in California, and of the highest quality. Peaches, pears, and quinces were also shown that were both beautiful and delicious. There were several new varieties of grapes on exhibition. Notable among these was

Woodruff. It is of the species *V. labrusca*, and somewhat resembles Dracut Amber, but is much better in quality. Indeed it is very finely flavored and is of a clear amber color. The berry is large and the bunch medium sized and compact.

Mr. C. P. Chidester, of Belleview, showed several seedlings, and among them one of very superior quality, that looked much like Catawba and tasted like Brighton. It was named Lyon by the examining committee in honor of Mr. T. T. Lyon, the noted pomologist of Michigan. It is well worthy of further trial.

I visited several places of interest at Grand Rapids. One mile north of the city, on a high hill, I saw one of the finest vineyards that it has ever been my pleasure to see anywhere. It was in a high state of tilth, and the vines were loaded with fruit. Worden was the most profitable variety grown there. The fruit of that variety was mostly marketed, but some of the vines were yet loaded. and afforded opportunity to see how it did. Certainly it is all that the Concord can claim to be in every respect, and more in some particulars. The Concord in this vineyard was barely fit to market when I was there (September 21), but the Worden was nearly gone. Besides, the fruit was larger and better flavored.

A peach orchard covered the crest and slopes towards all points of the compass. On the south and west sides and on the crest the trees were either dead or injured by the winter of 1885-'86. The greatest damage was on the southern slope. On the northern and eastern slopes there was a heavy crop of fruit then on the trees.

At the fair then in progress at Grand Rapids I saw a grand display of quinces, mostly from the western counties of the State. Plums were also shown equally as fine as those seen at Jackson. These were mostly from the region of Traverse Bay, to the northward, and near Mackinaw Straits. The apples, peaches, and pears were also large and luscious. Making my way northwestward about 100 miles farther, I spent some days in examining the fruits of the Grand Traverse region.

Here quite a different state of things was manifest. The condition of all fruits was much later than that in the regions South. The plum crop was about gone at that time, September 24, but I could see from the bent and broken branches something of their departed glory, and here and there was to be found a belated specimen. I took much pains to determine, if possible, the cause of their success. I examined the orchards and questioned the owners. Some had used the jarring process to catch the curculio. Others had sprayed the trees with Paris green and some with London purple. Occasionally one had tried all these plans. Many had done nothing to prevent the ravages of this little pestiferous insect. In all cases, including those in which no remedy had been tried, a crop of plums had been gathered. I came to the conclusion that nature had by some means cut short the numbers of this insect, and an abundance of fruit had been the result. But I was assured by many that this was an unusual circumstance, for nearly every year they have suffered a considerable diminution of the yield by reason of the curculio. All the orchard fruits seemed to be flourishing. Apple trees were bearing a full crop. Near Manistee, and in the region of Bear Lake, Frankfort, Benzonia, and Traverse City this fruit was comparatively free from insect or fungous affections. Some varieties, such as Fameuse or Snow and Swarr, were troubled with scab. But the lighter fungous disease, that give the apples a dirty appearance in the South and West, was not

apparent. It is too cool for its natural development. The apples of this region are especially good keepers. The very late and mild falls enable them to develop size and color and yet not hasten their ripening. Indeed, the climatic conditions of this section of our country are very peculiar, and I may say very favorable for many kinds of fruit. I gathered Carolina June, and Primate apples from the trees in the first week of October near Benzonia, and Grimes Golden and Colvert were quite eatable at the same time. The Baldwin does finely, but the Ben Davis and Winesap are out of their latitude. Pears grow luxuriantly. Some Sheldon trees that I saw were loaded with specimens that would grace any exhibition table. Peaches also do quite well. It seemed strange to gather peaches within fifty miles of Mackinaw, when six hundred miles south of there the cold of the previous winter had killed every peach-bud. The secret of the whole matter is the influence of the great lakes in tempering the atmosphere in winter, so that it is not so cold nor so dry as it is for many miles south of such influence. Grapes were just beginning to ripen when I left, about October 10. However, I saw some very fine little vineyards of Delaware and Agawam, in which there was no sign of mildew, black-rot, or any disease. The vines and fruit looked as clean and bright as if they had been washed every day. However, it is rather too far north for successful grape culture, except in very peculiar situations on southern and eastern slopes.

Before returning to my headquarters, I proceeded, under directions, to Springdale, Ark., where was being held a fair of the Arkansas State Horticultural Society. This place is in the northwestern portion of the State, and in the midst of the best apple-growing counties.

In size and beauty the apples of this section can rarely be equaled, because the soil and climate are well adapted to their growth; and much attention is now being given to this branch of pomology by the farmers. One thing that interested me particularly was the large number of seedling apples of high quality. I think fully fifty varieties were shown that were entirely new. Some of these are worthy of further trial by experimenters, and a very few of these are described and illustrated in this report, as well as some already somewhat known.

A meeting of the State Horticultural Association of Pennsylvania was held January 19 and 20, 1887, at which the Department was represented by the Pomologist. At that meeting there was a goodly number of the horticulturists of this great State, and the tables were covered with fruits. Notable among the apples shown was York Imperial, which is a native seedling of the vicinity of York, in that State. Although not a new variety, it is not nearly so well known as it should be. The fruit is of a bright red color and excellent flavor and keeping qualities. It also succeeds remarkably well both East and West as a profitable orchard variety. In Kansas and Missouri I have seen it doing remarkably well, and it is worthy of general cultivation. Its only defect is, that it is often of an irregular, or rather a diagonally inclined form, which is found objectionable when paring it on a machine.

The subject of "Nut Culture," and especially the chestnut, was discussed with much interest. The rough and worn-out fields of this State seem peculiarly suitable for nut trees. There are a few improved kinds of chestnuts, which are far more desirable as to size of the nut and early bearing than the common native varieties. Mr. H.

M. Engle, of Marietta, Pa., has one of special merit. It is much regretted that the pressing character of duties at Washington at this time did not permit a more extended visit and to different parts of the State.

On the 26th and 27th of January the Western New York Horticultural Society held a winter session, at which this division was represented.

This is one of the oldest and most active horticultural societies in the United States. The membership is large, and the attendance at this time was quite full. The display of fruit was especially fine. Messrs. Elwanger & Barry, of Rochester, were the principal exhibitors, and their show of pears was very choice. Such specimens of Anjou are rarely seen, even from California, and their flavor was of the very highest quality.

The show of apples was not large, but the varieties were mostly new and rare. Sutton Beauty and Belle de Boskoop were among them, and seemed to be in good keeping order. The Niagara grape was in excellent condition. This seems to be a grape of good keeping qualities. The Empire State was there, too, and its flavor even at that date (January 27) was very good. A new plum was shown by Mr. S. D. Willard, called the Stanton, which is a freestone and of most superior quality. It is worthy of further trial. The Jessie strawberry was discussed at length, and generally thought to be a variety of much promise.

NEW FRUITS.

The following rules are copied from the proceedings of the American Pomological Society and are most earnestly indorsed and urged upon the people as desirable to put in practice:

SECTION 1.—NAMING AND DESCRIBING NEW FRUITS.

Rule 1.—The originator or introducer (in the order named) has the prior right to bestow a name upon a new or unnamed fruit.

Rule 2.—The society reserves the right, in case of long, inappropriate, or otherwise objectionable names, to shorten, modify, or wholly change the same when they shall occur in its discussions or reports, and also to recommend such changes for general adoption.

Rule 3.—The names of fruits should preferably express, as far as practicable, by a single word, the characteristics of the variety, the name of the originator, or the place of its origin. Under no ordinary circumstances should more than a single word be employed.

Rule 4.—Should the question of priority arise between different names for the same variety of fruit, other circumstances being equal the name first publicly bestowed will be given precedence.

Rule 5.—To entitle a new fruit to the award or commendation of the society, it must possess (at least for the locality for which it is recommended) some valuable or desirable quality or combination of qualities in a higher degree than any previously known variety of its class and season.

Rule 6.—A variety of fruit having been once exhibited, examined, and reported upon as a new fruit by a committee of the society, will not thereafter be recognized as such so far as subsequent reports are concerned.

THE ORANGE.

Bahia. Synonyms: Washington Navel and Riverside Navel.

This orange is attracting the attention of the growers in Florida and California, and is being sought after by their customers in the Northern States. It was first brought to this country by importation rom Bahia, in Brazil, in 1870, by Mr. William Saunders, of thi

Department. There were twelve trees in this first and only importation, which were secured for him by a lady then traveling in Brazil. It was sent out by this Department under the name Bahia, but was by some changed to Washington Navel. Two of the first trees to bear, aside from the orange house of this Department, were on the grounds of Mrs. L. C. Tibbetts, at Riverside, Cal., and as buds were taken from these trees it got the name of Riverside Navel.

The accompanying colored illustrations were made from a specimen grown by Mr. E. H. Hart, of Federal Point, Fla., and are exactly life size. It is rarely that even one seed is found in a specimen, and the flavor of the fruit is par excellence. By some it is said to be a rather shy bearer. The investigation of this subject is now occupying my attention, and it is hoped that by another year we may have the matter quite conclusively settled. There is also such a wide diversity of opinion as to whether the name Bahia or Washington Navel should supersede, and it may be found best to accept the latter.

THE PEAR.

Le Conte.

This pear is now attracting much attention, especially in the South. In answer to a letter of mine, making inquiry as to the early history of this variety, the following was received from Mr. John L. Harden, of Walthourville, Ga.:

Maj. John Le Conte, of New York City (and afterwards of Philadelphia), in the year 1850 had a number of fruit trees and other plants put up for his niece (Mrs. J. L. C. Harden, my mother), of Liberty County, Georgia, at a nursery in New York or Philadelphia (most probably New York), and among them was a rooted cutting of what was marked "Chinese Sand Pear." Major Le Conte was informed by the proprietor of the nursery that the pear was only fit for preserving, as it never matured in this country. Contrary, however, to expectation, it matured in Liberty County, and proved to be a fine and productive pear. The original tree is now owned by my mother's heirs, and is still vigorous, although not cultivated in any way, and produces from 10 to 20 bushels each year.

So far as I know, there is no disease to which it is liable. I have known one of my own taken from the mother tree that died partially, but I allowed it to remain the whole season through, pruned off the dead branches in the fall of the year, and it is still living and is vigorous.

Size, large; shape, roundish, conical, tapering towards both ends; surface, smooth, yellow, no russet, no blush; dots, very numerous, small; basin, narrow and deep; eye, small, open, segments often drop off; apex, very slightly sunken; stem, medium length and stout; core, large, closed; seeds, large, light colored; flesh, very tender, juicy, rots at core; flavor, not rich, but pleasant, somewhat astringent; quality, medium, not equal to Flemish Beauty.

THE APPLE.

Arkansas Black.

This is a variety that has been making a favorable impression both in the region in which it is grown and upon pomologists who have investigated its qualities. Although I have not seen the tree, and do not know of it from personal experience, it is reported on good authority to be productive. There is scarcely an apple that is more brilliantly colored. The specimen here described and illustrated was grown in 1886 by H. B. Woolsey, of Bentonville, Ark.

Size, medium, 2½ to 3 inches; shape, round or slightly conical, reg-

ular; surface, smooth, glossy, yellow where not covered with deep crimson, almost black; no stripes visible; dots, small, light colored, shown through the dark over-color; basin, very shallow; eye, small, closed; cavity, rather shallow, narrow, russeted; stem, medium, slender; core, inclined to be loose or open, clasping the calyx tube; seeds, small, short, plump, light brown; flesh, very yellow, firm, fine grained, juicy; flavor, subacid, pleasant, rich; quality, very good; season, December to March in Arkansas.

Elkhorn.

The Elkhorn is an apple which originated on the old battle-ground of Pea Ridge, Arkansas, near Elkhorn tavern, and was given the name from that fact. It was brought to notice by G. F. Kennan of Brightwater, Ark., in the fall of 1886, and promises well.

Size, large to very large, often 4 inches in diameter; shape, flat, not conical, regular; surface, yellowish, well covered with rather dull mixed red and darker stripes; handsome but not brilliant; dots, numerous, very large, light gray, on distinct and lighter bases; basin, large, closed or nearly so; cavity, wide, deep, heavily russeted; stem, very short, slender; core, large, clasping, open; seeds, large, flat, dark colored; flesh, yellowish, firm, a little coarse, juicy; flavor, subacid, mild, pleasant, rich; quality, very good; season, December to spring in Arkansas.

Crawford.

This is an apple that is worthy of trial. It originated with James Crawford, of Boonesborough, Ark., and the specimen from which I made the accompanying drawing was from him.

Size, large, 3½ to 4 inches in diameter; shape, flat, very slightly conical, very regular in its outlines; surface, smooth, yellow, often beautifully blushed; dots, very prominent, numerous, large, light gray; basin, very deep, large, regular; eye, large, open; cavity, deep, wide, regular, heavily russeted; stem, medium length, slender; core, very small, compact, outer line indistinctly marked; seeds, short, plump, light brown; flesh, yellow, tender, fine grained, jucy; flavor, subacid, rich; quality, very good; season, December to March or later in Arkansas.

Siloam.

This is another of the new varieties that has been brought to notice in Arkansas. It originated on the farm of Mr. James Carl, of Siloam Springs, and is quite likely to prove a winter apple of excellent keeping qualities.

Size, medium, 2½ to 3 inches; shape, flat, regular, almost like Rawle's Genet; surface, smooth, yellow ground about half covered with rather dull red stripes and splashes; dots, numerous, small, light gray; basin, shallow, regular; eye, small, closed; cavity, shallow russeted; stem, very short; core, wide, nearly closed, clasping the calyx tube; seeds, small, plump, dark; flesh, yellow, fine grained juicy; flavor, subacid, rich; quality, almost best; season, December to spring in Arkansas.

Shannon.

There has been so much said lately about this variety that a description is here given, although it is not new. For many years

there has been some confusion of this variety with one known as the Ohio Pippin. But after carefully studying the specimens that I have received under both names, and examining the trees, I think they are distinct. The specimen from which I made the accompanying illustration and written description was grown by Mr. Garrett Williams, of Hinesville, Ark., in 1886. It was a fair average specimen in all respects, and came from near where the variety originated in that State.

Size, large to very large, 3 to 4 inches; shape, flat, conical, regular, or appearing a little elliptical when viewed from the end; surface, very smooth, yellow, occasionally faintly blushed, with a dull overcast of whitish blotches and streaks; dots, small, indistinct, white or light gray; basin, shallow, waved a little; eye, large to medium, open; cavity, shallow, regular, russeted; stem, very short, often fleshy; core, wide, open, clasping the calyx tube; seeds, short, plump, dark; flesh, yellow, rather coarse, juicy; flavor, mild, subacid, not rich; quality, good only; season, October to February in Arkansas.

Pilot.

This new seedling has been brought to notice in Albemarle County, Virginia. It grew up where some rotten Yellow Newton apples had been thrown out, and is supposed to be a seedling of that variety. As this occurred on a farm near the base of Pilot Mountain, it has been given the name Pilot. I am much pleased with its character, but it is yet to be proved valuable in other localities. It has been planted in some of the orchards in that locality, but seems to have the fault of being a very tardy bearer. Some trees have not fruited until over fifteen years old. This may prove a bad fault, but it is worthy of further trial.

Size, medium to large, 3½ inches; shape, round, regular; surface, smooth, the yellow under-color is almost hidden by dull mixed red and brighter splashes, over which is a grayish coating; dots, numerous, large, gray, often star-shaped; basin, deep, regular; eye, rather small, closed; cavity, shallow, narrow, slightly russeted; stem, short; core, closed or slightly open; seeds, plump, light brown; flesh, yellow, fine grained, firm, juicy; flavor, mild subacid, rich, aromatic; quality, very good or best; season, January to spring in Virginia.

Burlington.

One of the most richly colored and flavored apples that I have met with is a seedling of Grimes's Golden, originated by H. R. Teller (now deceased), of Albia, Iowa.

Size, small to medium; shape, round or truncate, regular; surface, rough, mixed red and russet on yellow ground; dots, small, gray, on large russet bases, especially those near the stem; basin, deep, folded, and very uneven; eye, medium, very widely open, segments short; cavity, narrow, shallow, much russeted; stem, very long and slender; core, small, narrow, closed, almost meeting the calyx tube; seeds, rather few, small, but very full and plump, light colored; flesh, very yellow, very fine grained, heavy but tender, juicy when fully ripe; flavor, very mild subacid, almost sweet, rich, aromatic; quality, best; season, December to spring in Iowa.

Northwestern Greening.

This apple is of Wisconsin origin, where it is being sought after on account of its fine appearance and reputed hardiness, although the latter is doubted by some who have grown it. However, it is worthy of trial.

Size, large, 3 to 3½ inches; shape, nearly round, very regular; surface, very smooth, often green, but yellow when fully ripe; resembles Lowell; dots, scattering, mostly dark, with some very light; basin, wide, shallow, a little folded or gathered; eye, rather large, open; cavity, medium, regular, a little russet in bottom; stem, medium, rather slender; core, large, nearly closed; seeds, small, plump, grayish brown; flesh, yellow, rather coarse, juicy; flavor, subacid; quality, good; season, December to February in Wisconsin.

Wolf River.

This variety will be remembered by many as one which is being well spoken of for the Northern part of the country. It originated in Waupaca County, Wisconsin, and was brought to notice by W. A. Springer, of Fremont, in that State. It is almost identical with Alexander in nearly all respects, and I have sometimes thought it is that variety. But the origin of Wolf River as a seedling is quite well established, the fruit seems to keep later, and the trees seem to have a different look, and prove hardier. It has been grown in several other States, where it has almost universally proven valuable. I made this drawing from a specimen received from Mr. Springer.

Size, large to very large, 3 to 4 inches; shape, flat, conical, regular; surface, smooth, mixed and splashed bright red on whitish-yellow ground, very showy; dots, scattering, light gray, large; basin, shallow, small; eye, medium, open, segments reflexed; cavity, deep, wide, very much russeted; stem, medium to short, stout; core, very large, wide, open; seeds, numerous, small, short, plump, dark colored; flesh, yellowish-white, tender, coarse, gets dry as soon as ripe; flavor, subacid, not rich; quality, medium only; season, November to February in Wisconsin.

Waupaca.

This is another variety that originated in Waupaca County, Wisconsin, whence it received its name. Mr. William A. Springer is the introducer, and my specimens are from the original tree on the farm of Elijah Wrightman. It is said to be very hardy, and is recommended for trial in the North.

Size, medium, 3 inches; shape, flat, a little conical, irregular, angular; surface, smooth, mixed, and diffused carmine, splashed with darker red on yellow ground; dots, small, very light, prominent; basin, narrow, not very deep, slightly waved; eye, medium size, open, segments reflexed; cavity, medium depth, wide at top, russeted; stem, medium to short; core, closed or slightly open, pyraform, meeting the calyx tube; seeds, wide, flat, short, dark brown; flesh, yellow, tender, juicy, coarse; flavor, subacid, pleasant; season, December to February in Wisconsin.

Scott's Winter.

We have here a variety that is a seedling brought to notice by Dr. T. H. Hoskins, of Newport, Vt. It originated near that place, and

seems to be esteemed in that locality and in some of the Northwestern States for the hardiness of the tree and its brilliantly colored fruit. Although it is a little too tart for dessert purposes, it is liked for cooking. It is called one of our native iron-clads. My specimens were from Vermont.

Size, small, 2½ inches; shape, flat, conical, irregular; surface, smooth, light yellow, almost hidden by bright red blotches and stripes; dots, exceedingly minute, almost undiscernible, light colored; basin, deep, narrow, waved; eye, small, closed; cavity, small, narrow, russeted; stem, medium to short, slender; core, small, nearly closed; seeds, small, plump, rather light colored; flesh, white, with sometimes a tinge of pink, tender, fine grained, juicy; flavor, subacid, quite tart, but pleasant; quality, good; season, December to spring in Vermont.

Antonovka.

This is one of the Russian varieties that is quite highly spoken of by Professor Budd and others who have grown it in Iowa and Wisconsin. Others think it is not a late keeper. My drawing is from a specimen given me by Mr. G. P. Peffer, of Wisconsin, which he obtained from Mr. A. G. Tuttle, of Baraboo, in that State.

Size, small to medium, 2½ to 3 inches; shape, flat, slightly conical, irregular; angular; surface, rough, yellow, slightly blushed or bronzed; dots, numerous, small, light; basin, rather shallow, abrupt, narrow folded; eye, wide open, segments short; cavity, shallow, narrow, lightly or not at all russeted; stem, very short, fleshy; flesh, greenish white, rather coarse, tender; flavor, subacid, not rich; quality, rather poor; season, October to January in Wisconsin.

Boardman.

A box of very handsome apples of medium size and quality was received from Mr. E. H. Purington, of West Farmington, Me., said by him to be from a seedling of the Dean, and which I named Boardman, in honor of the secretary of the Maine Pomological Society. Below is a description of one of the specimens:

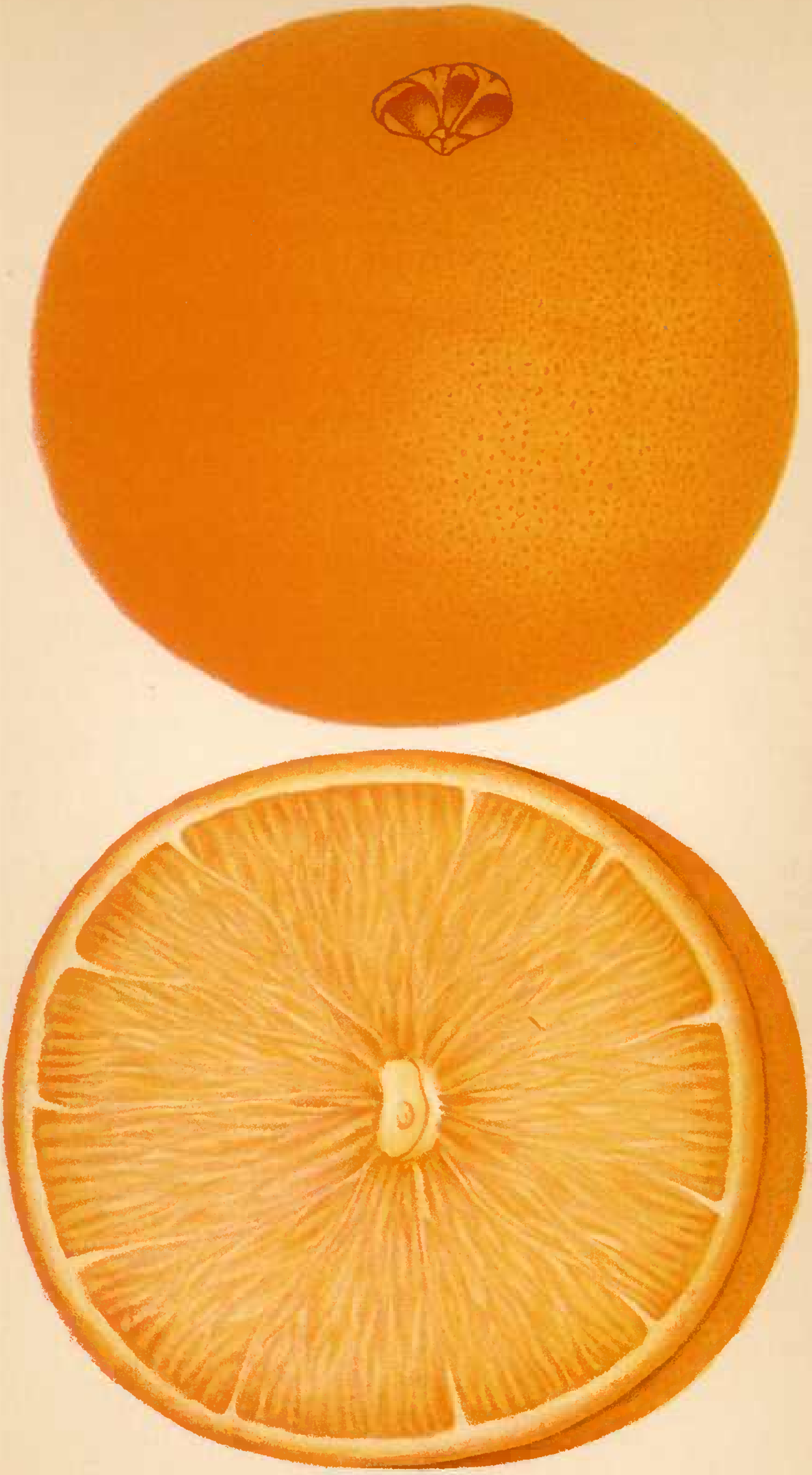
Size, small to medium, 2½ inches; shape, flat, conical, but not pointed, regular; surface, smooth, glossy, bright mixed and splashed carmine almost entirely covering a white ground; dots, not very numerous, gray, prominent; basin, medium, abrupt, regular, slightly marked with russet or leather-cracked; eye, small, partially open; cavity, deep, narrow, furrowed, but little russeted; stem, long, slender; core, small, closed; seeds, broad, plump, sharply pointed, dark; flesh, very white, tender, fine grained, juicy; flavor, subacid, not rich; quality, good; season, December to spring in Maine.

THE PLUM.

Kelsey's Japan.

This variety is becoming quite famous as a fruit of high quality, and an abundant and early bearer. It is from 2 to 2½ inches in diameter, and heart-shaped. Its color is rich yellow, with a tint of purple. But it is quite tender, and should not be planted north of Tennessee. Mr. Munson, of Denison, Tex., says that the hard freeze

Plate Nº I.



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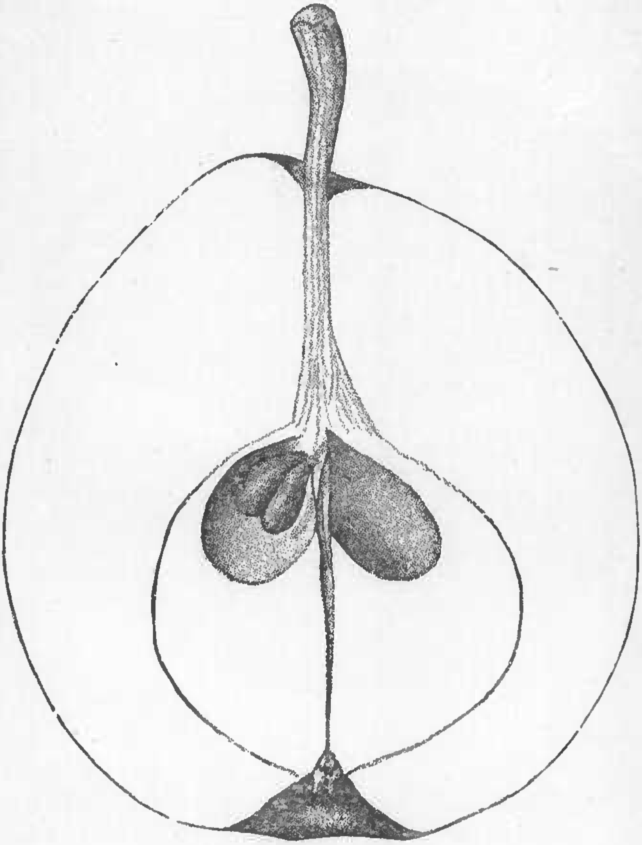
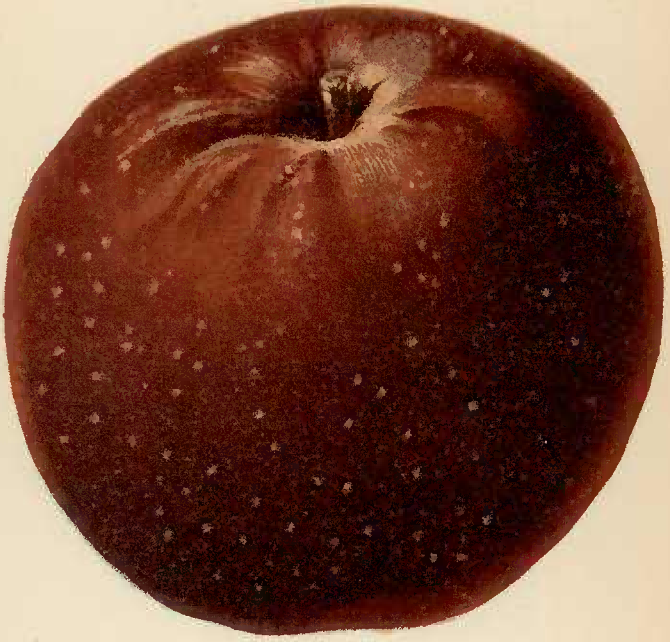
BAHIA, OR (WASHINGTON NAVEL).



Le Conte.



ARKANSAS BLACK.

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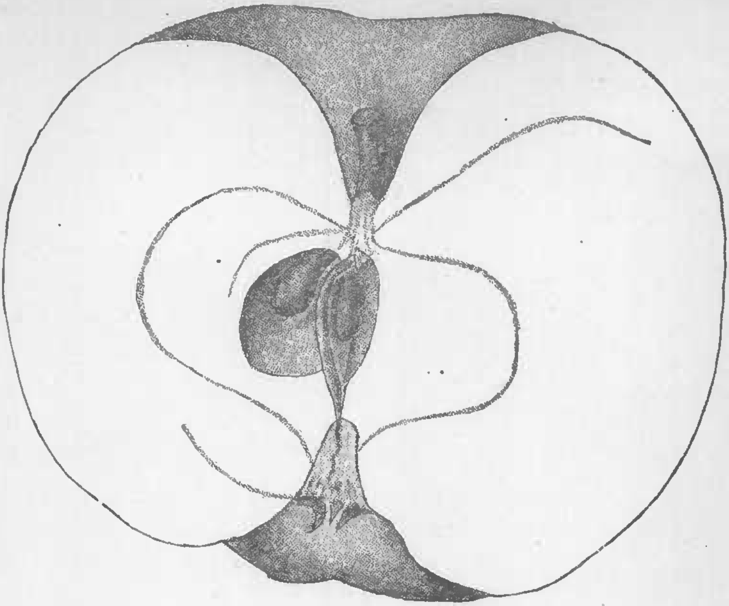
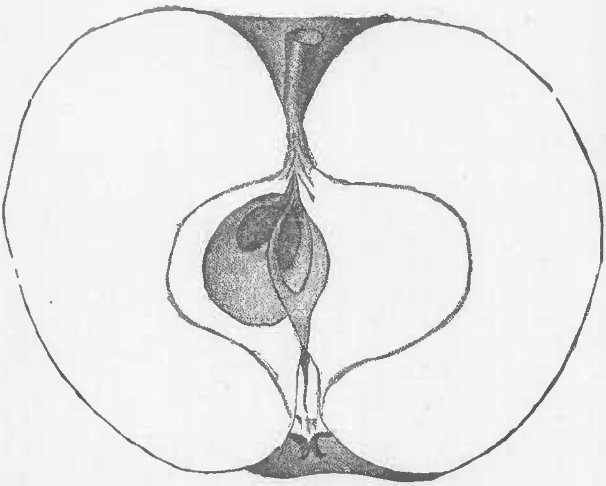


ELKHORN.



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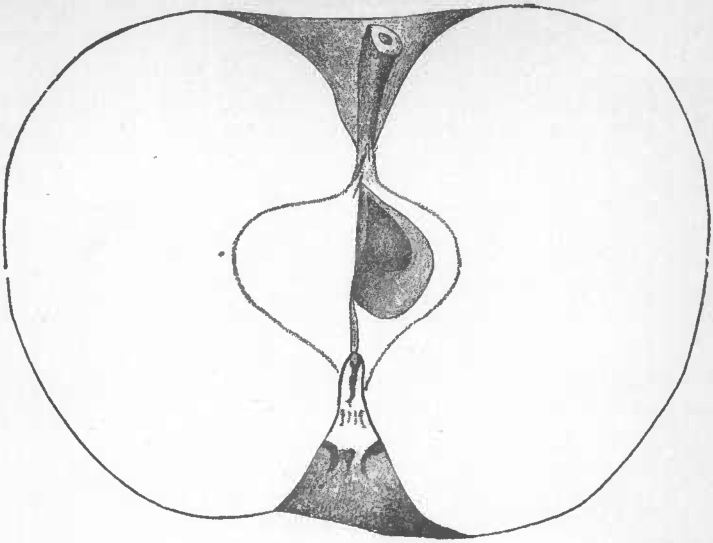
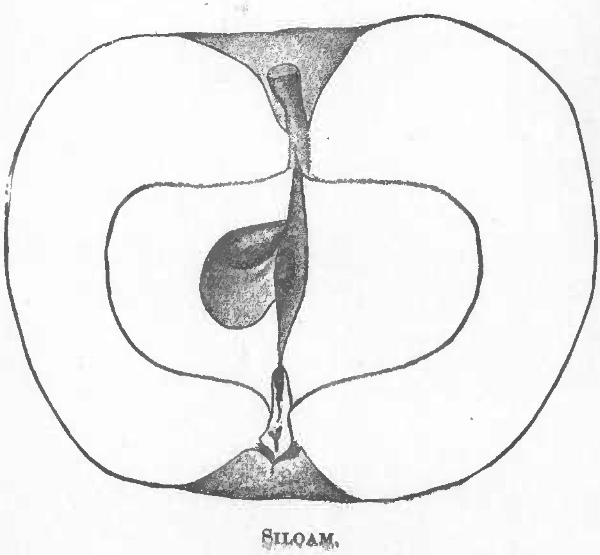
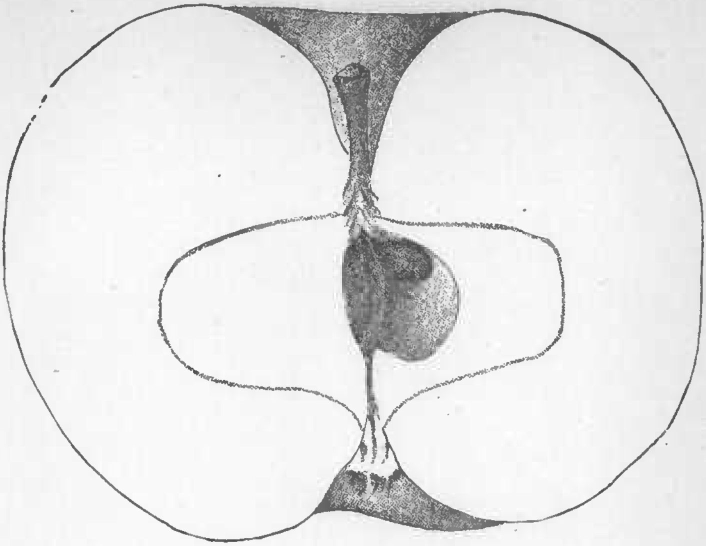


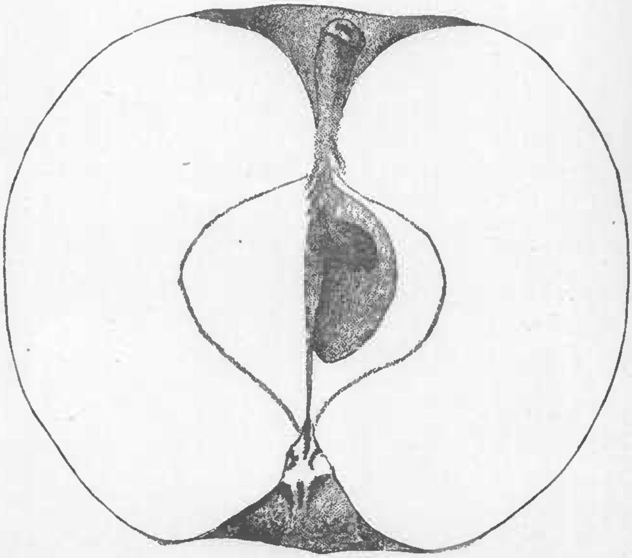
CRAWFORD.



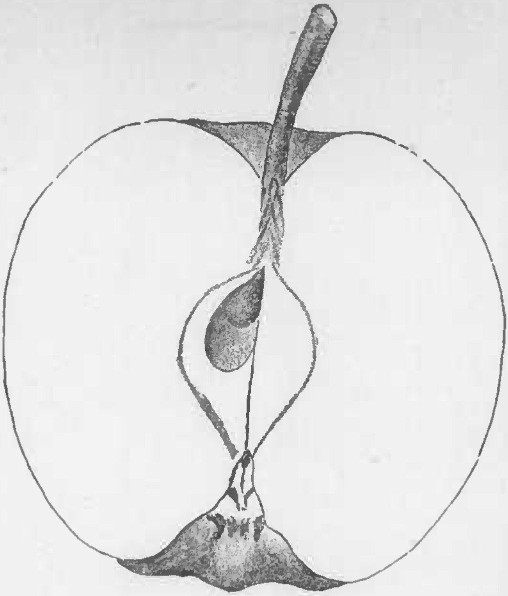
SILOAM.



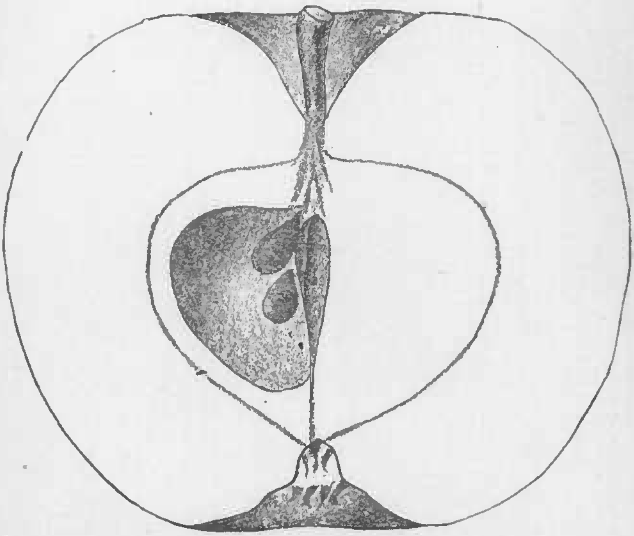
SHANNON.



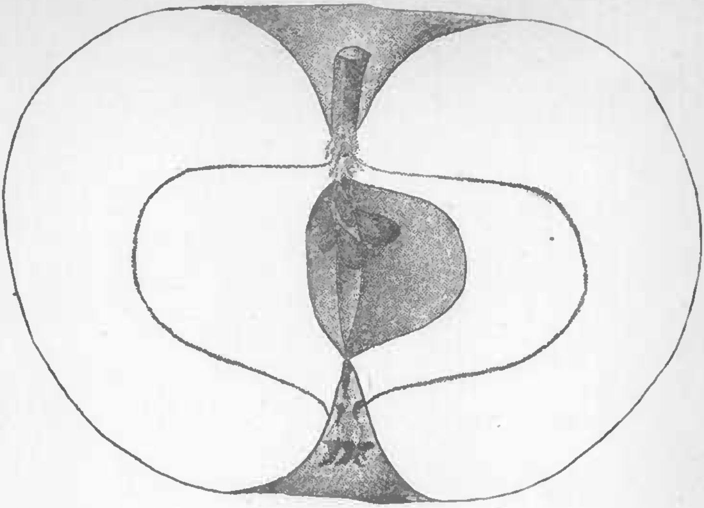
PILOT.



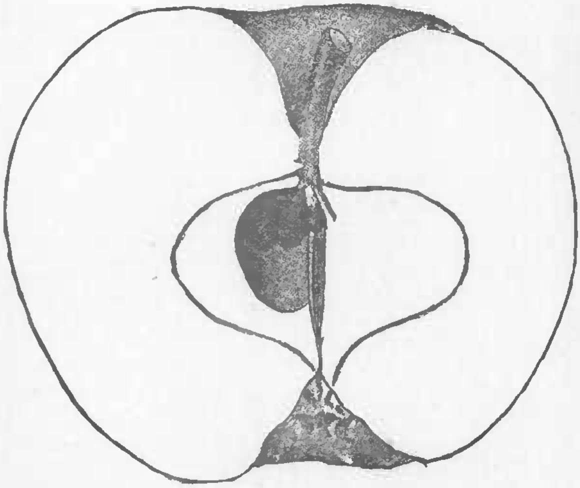
BURLINGTON.



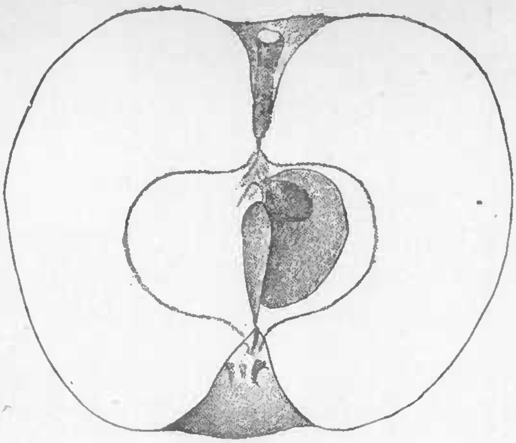
NORTHWESTERN GREENING



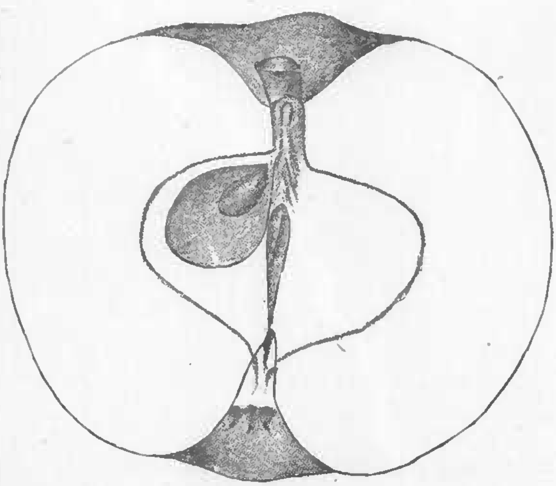
WOLF RIVER.



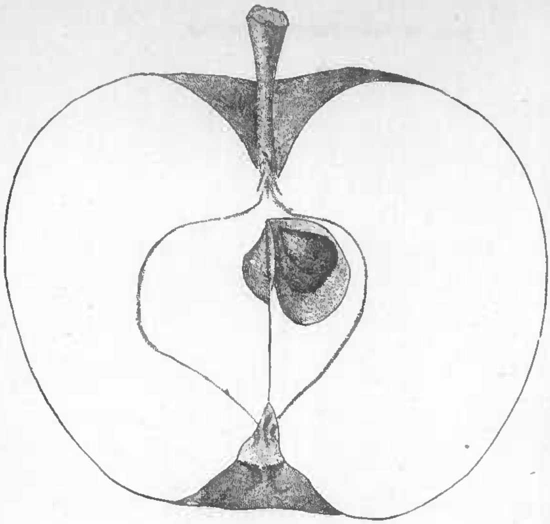
WAUPACA.



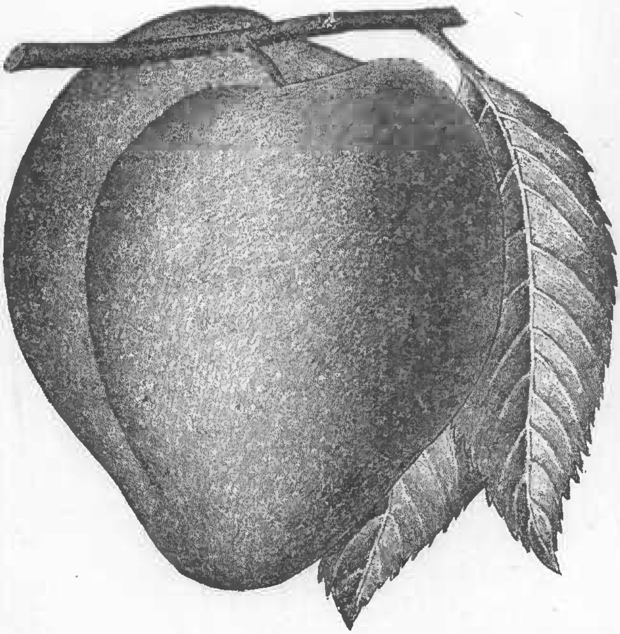
SCOTT'S WINTER.



ANTONOOKA.



BOARDMAN.



KELSEY'S JAPAN PLUM.

of January 7, 1886, killed young trees of this variety there. Mr. Kizo Tamari, of Japan, says that it is too tender to succeed in the northern part of that country. To determine the botanical name of the species to which this variety belongs has puzzled all the botanists in the United States so far as I know. There are no specimens in the herbariums of the country that give us any light, and Mr. Kizo Tamari has repeatedly stated to me that he does not think it belongs to any of the species native in Europe or America. This is a matter that is now engaging my careful attention.

Prof. E. W. Hilgard, of the University of California, under date of January 22, 1887, writes the following relative to this plum:

Your letter of inquiry regarding the antecedents of the "Kelsey Japan Plum" is duly received. I have requested Mr. E. J. Wickson, lecturer on agriculture and horticulture in this institution, to give you an account of the history of the fruit so far as known to him, and I inclose herewith his remarks thereon.

I became acquainted with the fruit in 1876, when I planted my home orchard here, for which Mr. John Kelsey, my near neighbor, supplied the trees, among them two of the Japan plums. They were at the time badly infested with the oyster-shell scale, a species that does not usually attack plums, and it was not until four or five years after planting that I succeeded in freeing the trees entirely from the pest. Since then they have done well and have borne regularly, but in their own peculiar fashion. In this climate the tree is never entirely without leaves, to-day the ends of the branches are leafy and green, and the old leaves will fall only when the new buds begin to swell. The first blossoms usually open when the leaves are about half grown and so continue for several weeks, new blossoms opening sometimes when the first have already fruit nearly an inch long. The result is that the fruit likewise ripens consecutively, a very convenient habit for family use, but rather objectionable for culture on a large scale. I hear that the same experience has been had by others on heavy soil similar to mine here, while on lighter soils it seems to be more regular in its habits.

I have not looked into its botanical relationship, nor attempted its identification with the described species of *Prunus* from Japan. Of American plums it resembles in habit very nearly the *P. chicasa*, for which in the absence of fruit it might readily be mistaken. I will look into the characters of the other alleged Japan plums mentioned by Mr. Wickson, and communicate results to you.

Mr. Edward J. Wickson, of the Agricultural College at Berkeley, Cal., makes this memorandum on "Kelsey's Japan Plum:"

The fruit was first shown to me during the last week in August, 1877, by the late John Kelsey, of Berkeley, Cal. He informed me that the fruit was introduced to this State through the efforts of Mr. Hough, of Vacaville, Solano County, then deceased, in 1870; and that Mr. Hough secured the trees through Mr. Bridges, at that time United States consul in Japan. The trees cost $10 each and Mr. Kelsey informed me that he obtained all the stock from Mr. Hough.

It is my impression that Mr. Kelsey left the trees standing in the nursery rows until fruit appeared. I am not sure how soon they first fruited, but I remember that Mr. Kelsey told me that he had expected to show the fruit sooner, but it had been taken by squirrels and intruders. The samples shown me in 1877 were picked a little short of maturity to secure them. Mr. Kelsey was assured of the value of the variety and propagated it to some extent. One thing which he conceived to prove the tree of special value was the fact that in the dry summer of 1877 his Japan plum trees were vigorous and productive, while some other varieties (the Columbia and Yellow Egg being specified) suffered severely from the drought. On a branch which Mr. Kelsey showed me there were six plums wedged tightly together on six inches length of wood. The good points which Mr. Kelsey saw in the fruit and in the tree led him to propagate it to a considerable extent.

The name "Kelsey's Japan Plum" was not given to the fruit until after Mr. Kelsey's death, and was then placed upon it by those who desired to honor his memory and to make fitting recognition of his good work in pomology. The propagation of the variety was undertaken on a large scale in 1883 by W. P. Hammon & Co., of Oakland, Cal., who obtained the stock from the heirs of Mr. Kelsey. The first large sale of trees was for the planting season of 1884. Although the stock had been in the hands of other nurserymen and growers for some years before that time, its wide distribution dates from that year.

There are a number of other 'Japan plums' in the hands of California growers.

which, however, are quite different from the 'Kelsey.' The Loquat is often called a Japan plum, but I do not intend to include that fruit. Mr. A. D. Pryal, of North Temescal, has shown at the fairs and at the meetings of the State Horticultural Society several plums of Japanese origin. They vary considerably in form, size, and color from each other, and are all more regular in outline than the Kelsey. Mr. Pryal has Japanese names for them. Mr. James Shinn, of Niles, Alameda County, also has a collection of Japanese plums, varying in color from lemon yellow to dark red, and very different in flavor; one variety I remember is of especial sweetness.

The Kelsey Japan Plum has been worked on different stocks by our nurserymen, and there is some difference of opinion as to results. Considerable plantations have been made, but I am not aware that the market value and adaptations of the fruit have yet been fully determined.

ORCHARDING IN NORTHERN NEW ENGLAND.

By T. H. Hoskins, M. D.

By request of the Pomologist of the Department of Agriculture I am induced to give a sketch of the introduction of the culture of tree fruits into those parts of New England adjacent to the Canadian Dominion. All of this section of country has been settled during the present century, and most of it within fifty years. The first considerable advent of population into Northeastern Vermont was about the period of the war of 1812. This continued subsequently until the population in 1860 was nearly as dense as in any part of the State.

The early settlers made frequent attempts to grow the tree fruits of their native States, and not without success, until they got as far north as the mouth of Passumpsic (about 44 degrees North). Up to this point even the Baldwin can be grown, top-grafted into hardier trees, in favorable spots, but not profitably, on the commercial scale, far above the mouth of the White River (about 43 degrees North). The Baldwin, with the Rhode Island Greening and Roxbury Russet, but little hardier, are the great market apples of New England; and it was difficult to find anything to adequately replace them, though the McLellan of Connecticut, Jewett's Fine Red (Nodhead) of New Hampshire, and later the Northern Spy and the Bethel (the last a native seedling of the Connecticut Valley town of that name), were adopted as substitutes to some extent.

Following up the Passumpsic Valley nearly due north, and rising fast in altitude, the last towns in which orcharding was made even moderately successful, until within the last twenty years, were Barnet, Peacham, and Danville, in Caledonia County. Those who pushed over the divide and settled Orleans County, south of and around Lake Memphremagog, though they planted many seedling orchards, occasional trees of which maintained a struggling existence, never were able to produce marketable fruit to any appreciable extent, and until the advent of the railroad, about 1862, good eating apples were about as much of a rarity as oranges there. It may as well be noted here that the apple-producing region of the Saint Lawrence River extends not far below Montreal and only a few miles up the tributary valleys of the south bank. The altitude of Lake Memphremagog is about 800 feet above the sea, but the country around it rises from that to 1,500 feet, at which last-named height are found many of the best dairy farms. In the same latitude, 50 miles west, on Lake Champlain, less than 100 hundred feet above the sea, in a low valley extending from the Atlantic at the mouth of the Hudson to Montreal, all the tree fruits of lower New England, except the peach, are successfully grown. This difference in altitude is fully equivalent to three degrees of latitude in its effect on orchard fruits.

About the year 1864 a number of improved Siberian crab seedlings—most of them evidently a cross with the Fameuse, so extensively grown about Montreal—were introduced from Canada, and planted in Orleans, Essex, and Caledonia Counties. These were the first apple trees genuinely successful in that section. They were peddled at $1.50 each, and were eagerly bought. One dealer claimed, I have no doubt truly, to have sold $42,000 worth in a single year. Three years afterwards the writer planted on his farm, near Newport, on the lake, an orchard, in which were set the Tetofsky, Duchess of Oldenburgh, Red and White Astrachan and Alexander—all Russian apples, which had been grown many years in Eastern Massachusetts, from whence he had removed the previous year. To these were added many of the crab hybrids, and an apple from Montreal, some time before imported from Normandy, in France, and now known to pomology as the Peach of Montreal. Besides these, thirty other varieties, called the hardiest in Maine, New Hampshire, and Canada, were planted. Among these the only true iron-clad found was the Bethel of Vermont, though Fameuse, Ben Davis, and Sops of Wine have proved sufficiently

resistant to the climate to yield a little profit. Both Red and White Astrachan and Alexander have proved unprofitable, the first and last being not quite hardy, and the other not productive enough for profit.

None of the successful apples in the above list are keepers except Bethel, which, like Northern Spy, is very tardy in coming into full bearing. In 1870 a large number of scions from Russian trees, imported by the United States Department of Agriculture, were sent into Vermont for trial. The only persons who seem to have taken any pains to test these were Aaron Webster, of Roxbury, Vt., and the writer. Mr. Webster received by far the larger assortment, and, having a large orchard, he was able by top grafting to get fruit from most of them in a few years. My own were root-grafted, and did not come to bearing so soon. It was soon found that these Russian apples were to make most valuable additions to our list of summer and fall varieties, but among them all (I refer to those sent to Vermont) only two genuine all-winter apples were found. These are the Borsdorf (341) and Little Seedling (410). The chief merit of the latter is in its remarkable keeping quality, so rare among the Russians. It will "keep until apples come again" with little care, and being quite iron-clad, ought to be utilized as a mother-tree to grow crossed seedlings from. The Borsdorf, though only of medium size with good culture, is of nice appearance and excellent quality. If it had not been for the advent of the Wealthy it would have received much more attention than it has.

The purpose of this paper is not to give a detailed description of hardy fruits, but merely to outline the history of their introduction, and of their successful culture, in Northern New England. Though the writer came to Vermont from Massachusetts, he is a native of Maine, and as soon as he had solved the problem of apple culture for Northern Vermont, his thoughts turned to the vast and fertile Aroostook region of that State, covering an arable territory as large as the whole of Vermont. Even the southern boundary of that section is 100 miles north of the north line of Vermont, but its much less altitude (scarcely anywhere more than 300 feet above the sea) and its proximity to the ocean prevent the winter's cold from being greater there than here. A nurseryman in Woodstock, New Brunswick, had distributed some of the early imported Russian apples and the Fameuse in Southern Aroostook, as well as some of the hybrid Siberians, about 1868, and these were the only apples grown there when, in 1872, I began to send scions to the addresses of Aroostook farmers whom I found mentioned by the Maine agricultural press as attempting to grow apples. This I have continued, and twice, at the invitation of the secretary of the Maine Board of Agriculture, I have visited Aroostook and taken part in the discussions in the board's meetings on the subject of orchard culture. In this way I have become somewhat acquainted with the resources of this, by far the finest, as well as the most extensive, agricultural region of New England. For dairy, stock, and fruit farming Aroostook is inferior to Western New York and Ohio only in its colder winter temperature. It is now being settled with considerable rapidity, and everywhere the planting of orchards of iron-clad apples keeps pace with the opening of farms.

New Hampshire tapers northward as Vermont tapers southward in territory, only more sharply; yet its northern county, Coos, possesses a large amount of excellent farming land, much of which is already improved. Here, too, the iron-clad apples are being extensively planted, and already the home market is being supplied, as in Northern Vermont, with home-grown apples. The upper Connecticut Valley is admirably adapted to orcharding, and will in the end contribute largely to the fruit supply of the large towns and villages of that State.

The Wealthy apple, originated in Minnesota by Peter M. Gideon, is not only the leading triumph in this line, but its appearance has taught us the most hopeful line of future advance in growing seedlings for the cold North. It has shown the rapid the improvability of the Siberian and Russian class of apples under crossing and with careful selection of seedlings. Although in the Upper Mississippi region of Northern Iowa and Minnesota the heat of autumn makes the Wealthy only a late fall or early winter apple (as Southern New Jersey in the same way transforms New England's long-keeping Baldwin), it is found in Northern New England that with early gathering and proper handling it keeps and preserves its quality until the last of March where it is grown. But it will not do this when exposed to the contingencies of transportation; and for shipment, wherever grown, it cannot be classed with the long keepers. The only genuine long-keeping iron-clad, possessing the necessary productiveness, along with other qualities of a shipping apple, which I am yet acquainted with, is a native seedling of this town, scions of which I have distributed widely under the name of Scott's Winter. But the future leading winter market apple of the cold North must surpass Scott's Winter in size and in dessert quality, and I am anxiously looking to Mr. Gideon's extensive seedling orchards, produced under his system of crossing, for the desired apple. He has already announced a seedling of the Wealthy almost duplicating its other qualities, with a longer season,

which he calls the "Peter," and I believe he, or some other Northwestern experimenter, proceeding on the same principle, will soon give us a Northern equal (or superior) of the Baldwin. This is alone needed to give the cold North the lead in orcharding, for it is a well-ascertained fact that the long days of our Northern summers are in the highest degree favorable to that combination of high color, delicate texture, and fine aroma which sells an apple at sight in every market of the world. Already the Wealthy is being shipped to England from Canada with profit, and a long-keeping Wealthy is all that is now required to become the leading commercial apple of America.

NEWPORT, VT., *January* 14, 1887.

ACKNOWLEDGMENTS.

It is a pleasure to acknowledge the kind and helpful spirit which has been manifested by every one with whom I have had to do in the work of practical investigation and in the preparation of this report. Among these may be mentioned Prof. T. V. Munson, Mr. and Mrs. J. R. Johnson and J. R. Howell, of Texas; Profs. E. Hilgard and George Husmann, of California; Prof. W. H. Ragan, of Indiana; Mr. F. W. Loudon and George P. Peffer, of Wisconsin; George W. Campbell and W. N. Irwin, of Ohio; G. F. Kennan, of Arkansas; E. H. Hart, John Anderson, and C. B. Magruder, of Florida; E. B. Engle, of Pennsylvania; S. M. Wiggins, of Louisiana; T. H. Hoskins, of Vermont; C. W. Garfield, T. T. Lyon, J. W. Van Deman, and W. G. Voorheis, of Michigan. Many others might properly be added to the list of those who have done what they could to help carry on the work.

Respectfully submitted.

H. E. VAN DEMAN,
Pomologist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

REPORT OF THE CHEMIST.

SIR: I have the honor to submit the following summary of the work done in the Division of Chemistry during the year 1886.

DAIRY PRODUCTS.

A careful study has been made of the best methods of determining the foreign fats which are used in the adulteration of butter.

The expressions "fats" and "oils" designate those natural products of animals and vegetables known as glycerides. Chemically considered they are the normal propenyl ethers of the fatty acids, or, in other words, compounds of the triad alcohol, glycerine, with the fatty acids. The term "fat" is applied to such bodies when they are solid at ordinary temperatures, and "oil" when they are semi-solid or liquid. Those which are most important are:

Tri-stearin, $C_3H_5(C_{18}H_{35}O_2)_3$, occuring in natural fats. It may be obtained in a considerable degree of purity by repeated crystallizations from ether. It crystallizes in plates of a pearly luster. Its melting point is 55° C.

Tri-palmitin, $C_3H_5(C_{16}H_{31}O_2)_3$, is found in animal fats and palm-oil. It crystallizes with a pearly luster from ether. The crystals have a melting point of from 50° to 66° C.

Tri-butyrin, $C_3H_5(C_4H_7O_2)_3$, occurs chiefly in butter. At ordinary temperature it is liquid, and has a distinct and peculiar odor and taste.

Tri-olein, $C_3H_5(C_{18}H_{33}O_2)_3$, occurs in animal fats and in almond and olive oil. At ordinary temperatures it is liquid, neutral to test papers, and has neither taste nor smell.

Minute quantities of tri-myristin, tri-caprin, and tri-caprylin are also found in butter.

Pure butter fat is supposed to contain:

	Per cent.
Of tri-olein, about	42.5
Of tri-stearin, about	51.0
Of tri-butyrin, about	6.3
Of other glycerides, about	.2
	100.00

Olive oil is composed chiefly of tri-palmitin and olein. Tri-stearin is the chief constituent of mutton fat, it having only small quantities of olein and palmitin. Beef fat has somewhat more palmitin and stearin than mutton tallow. Lard has more olein. It is thus seen that in dealing with butter fats and their substitutes we have to consider chiefly tri-olein and stearin, and, in smaller quantities, tri-palmitin, butyrin, &c. It follows, therefore, that the chief differences in the general characters of these substances will be due to the different proportions in which these glycerides are mixed and to such other physical differences as the various sources of the substances

under examination would produce. These differences, however, happily appear greater when subjected to the analysis of polarized light than the foregoing résumé of their chemical properties would indicate. In other words, the physical differences in the various natural fats are as important as the chemical. Advantage has been taken of these differences of physical structure to discriminate between fats and oils of different origins. The specific gravity and the melting point furnish two valuable points of discrimination, but both of these are perhaps inferior in value to the evidence afforded by the crystalline structure of the fats. The observation with the microscope of the crystals obtained in various ways furnishes valuable data for discrimination, and if polarized light and a selenite plate be used, these data become still more valuable.

The first account of the use of the selenite plate in such examination was given by Dr. J. Campbell Brown in the *Chemical News*, Vol. 28, page 1. He gives the following directions for the polaromicroscopic work:

Examine several portions of the original samples by means of a good microscope, using a one-quarter or one-fifth inch object glass. In butter made from milk or cream nothing is seen except the characteristic globules and the granular masses of curd and the cubical crystals of salt. The hard fats of butter are present in the globules in a state of solution, and are not recognizable in a separate form.

If stearic acid, stearin, or palmitin be present in separate form, they will be recognizable by single fusiform crystals, or star-like aggregations of acicular crystals. They indicate the presence of melted fats.

Other substances, such as starch, flour, palm-oil, corpuscles, Irish moss, coloring matter, &c., may also be distinguished by the microscope, as distinct from butter or fats.

Examine the same portions with the same object glass, together with a polariscope, consisting of two Nicol's prisms and a selenite plate. The crystals referred to polarize light, and when viewed by the polariscope are distinctly defined. Particles of suet and other fats which have not been melted may also be distinguished by their action on polarized light, by their amorphous form, and by their membranes.

The value of this deportment of fresh butter fat with elliptically polarized light did not meet with the appreciation its merits deserved until attention was again called to it by Dr. Thomas Taylor, of the Department of Agriculture.

Any fat or oil which is homogeneous and non-crystalline will present the same phenomena when viewed with polarized light and selenite plate; in other words, will have no effect on the appearance of the field of vision. It is only, therefore, fats which are in a crystalline or semi-crystalline state that can thus be distinguished from fresh, amorphous butter. Naturally it follows that a butter which has been melted and cooled, or butter which has stood a long time, would impart a mottled appearance to the field of vision. For a simple preliminary test, however, the procedure is worthy of more attention than its discoverer, Dr. Campbell Brown, accorded to it.

FORMS OF FAT CRYSTALS.

The forms of fat crystals differ greatly with the kinds of fat and the proportions in which they are mixed. It would be idle to attempt a description of all these modifications.

Husson (Ann. d. Chem. et d. Pharm., 5, 12, 469) has published an illustrated description of some of the more important fat crystals. Suet crystals, according to Husson, are very characteristic of stearin. They are small rounded or elliptical masses, formed by stiff, needle-like crystals, and resemble a sea-urchin or hedge-hog.

In lard are seen polyhedral cells, arising from the compression of the fatty globules. In impure lard are also seen the remains of cells and adipose tissue. Fresh butter shows some long and delicate needles of margarine (?), united in bundles and grouped in various ways. When the butter is melted these needles diminish in length and become grouped round a central point. I have mentioned these descriptions especially for the purpose of calling attention to the fact that in the illustrations of the microscopic appearance of butters and other fats emphasis is often given to one particular phenomenon and the real appearance as seen in the microscope is not reproduced.

The only reliable representation is found in the actual photomicrograph or its exact graphic reproduction.

When the crystals of certain fats are prepared in a special way they show, with polarized light, a distinct cross, the existence of which is explained by the laws of elliptical polarization already mentioned.

This cross was first described by Messrs. Hehner and Angell in 1874, in the following words:

> If some of a fat containing crystals be placed on a slide and a drop of castor oil or olive oil be applied and pressed out with a thin glass cover, the depolarization of light is much enhanced; a revolving black cross, not unlike that in some starch grains, is seen in great perfection. These crosses are most clearly defined in the crystals obtained from butter, and these thus mounted form a brilliant polariscopic object.

They add further:

> Thus far, and no further, as it seems to us, can the microscope assist us in this matter; but even such indications are valuable, especially when subsequent analysis proves the sample to be an adulterated article. The microscopic evidence in such a case frequently serves to clinch together the whole superstructure, and thus certainty is made doubly sure.

Dr. Thomas Taylor has further called attention to this phenomenon in a paper read before the American Society of Microscopists at its Cleveland meeting, August, 1885. On page 2 of the reprint of this paper he says:

> Since the publication of that paper I have experimented largely with butter, and have made the discovery that when it is boiled and cooled slowly for a period of from twelve to twenty-four hours at a temperature of from 50° to 70° F., it not only becomes crystallized, but with proper mounting and the use of polarized light it exhibits on each crystal a well-defined figure resembling what is known as the cross of St. Andrew. In course of time, the period ranging from a few days to a few weeks, according to the quality of the butter used and the temperature to which it is exposed, the crystals, which at first are globular, degenerate, giving way to numerous rosettelike forms peculiar to butter.

On page 5 he says:

> About ten years ago, while making some experiments with boiled butter, I first observed it exhibited small crystals somewhat stellar in form, but gave no further attention to the fact until May last. For the purpose of determining the real form of the crystal of boiled butter I procured a sample of pure dairy butter from Ohio. I boiled it, and when cold examined it under a power of 75 diameters. To my surprise I found globular bodies. When I subjected them to polarized light a cross, consisting of arms of equal length, was observed on each crystal.

Prof. H. A. Weber, of Columbus, Ohio, has made some interesting experiments with the microscope on fats, which, in the main, bear out the conclusions of Messrs. Brown, Hehner and Angell, and Taylor. As was to be expected, however, he has shown that the appearance of the cross on a crystal of natural fat does not show that it was

derived from pure butter. He says, in Bulletin No. 13 of the Ohio Experimental Station, Experiments 7, 8, 9, and 10:

Experiment 7.—The difference between the behavior of the tallow fats in Experiment 3 and the last three experiments could only be ascribed to a difference of conditions. It is well known that table butter normally contains 4 to 6 per cent. of salt and 5 to 20 per cent. of water. These ingredients constitute the most marked difference between butter and the rendered animal fats, as tallow and lard. In order to test the effect of this mixture upon the tallow fats, about half an ounce of the oleo oil used in Experiment 3 was mixed in a porcelain mortar with a small quantity of salt and eight or ten drops of water. After the water was thoroughly incorporated the mass was transferred to a test tube and boiled for one minute, as in the case of butter. It was then poured into a wooden pill-box and allowed to cool as before. The cooled mass presented quite a marked difference in appearance from that obtained from the same substance in Experiment 3. It retained to a great extent the yellow color of the oleo oil, was of a more granular nature, and in fact resembled boiled butter in every respect. When a small particle was stirred up with olive oil on a glass slide it separated readily. When covered and viewed with a pocket lens it revealed a mass of globules resembling insect eggs. Under the microscope these exhibited essentially the same characteristics as those obtained from butter in Experiment 1. The crystalline mass of the oleo globule seemed somewhat coarser, and to this condition was ascribed the fact that the cross. as well as the colors produced by the selenite plate, were less sharply defined than in the globules obtained from butter. The slides prepared from this material were remarkably free from the small detached crystals of fat observed in Experiment 3.

Experiment 8.—Having thus discovered that these globular masses may be obtained from pure yellow fat by simply observing the conditions which obtain in butter making, the following test was made: Nine grams of oleo oil and one gram of lard were placed in a small beaker, and eight or ten drops of a saturated solution of salt in water added. The mixture was then gently heated to melt the fats. After shaking violently for a few moments to mix the salt solution with the fats, the mixture was boiled gently for one minute, and then allowed to cool, as before, in a wooden pill-box. The microscopic examination of this preparation revealed globular masses which could in no wise be distinguished from those obtained from pure butter. The crystalline texture was dense, the cross of St. Andrew plainly marked and the colors produced by the selenite sharply defined.

Experiment 9.—A mixture of one part of lard to five parts of oleo oil was treated as in the last experiment with like results.

Experiment 10.—In this test a mixture consisting of 20 per cent. of lard and 80 per cent. of oleo oil was employed. Whether the consistency of this mixture was peculiarly adapted to the formation of the globules or whether possible variations of conditions in manipulations were more favorable the writer is unable to judge from a single experiment, but the fact is that in this case the individual "butter crystals" were exceedingly large and characteristic.

In Bulletin No. 15 of the Ohio Experimental Station, Professor Weber shows that the conclusions in respect of the origin of fat crystals and the behavior of butter and other fats under polarized light contained in his Bulletin No. 13 and in this paper are correct in every particular.

Specific gravity.—The specific gravity of a fat is a physical property of considerable importance in determining its character. For instance, the specific gravity of butter fat is uniformly higher than for any of the common fats used as adulterants therefor. Since the fats used for butter substitutes all melt at about 40° C. or under it is convenient to select that temperature for the determination of specific gravities. Many investigators, however, make the determination at 100° F. We have found that a pure butter fat has a specific gravity at 40° of .909 to .912, water at the same temperature being taken at 1.000.

On the other hand, butter substitutes show a comparative density of .900 to .905.

In these conditions it would be reasonable to suppose that a butter having less than .909 for specific gravity is adulterated, and the degree

of adulteration would be indicated by the number expressing the relative weight. In order that these numbers give reliable results it is necessary that the manipulation whereby they are obtained be made with the greatest care.

Melting point.—The melting point of a fat is also a physical property which is of value in determining its character. Unfortunately the methods heretofore in use for determining the melting point have not been reliable.

The difficulty has been to fix upon a point that really represents the passage of the fat from a solid to a liquid state. Since, however, in this transit the fat passes through all the grades of solid, semi-solid, and liquid, it has been found impracticable to fix the point with any degree of definiteness.

I have sought to overcome this difficulty by fixing on some definite physical phenomenon which can be observed with a considerable degree of accuracy.

Since fats pass gradually from a soft solid to a mobile liquid, it occurred to me that the point at which the molecular attraction of the particles overcome the molecular adhesion might be determined. In order to do this, however, it was necessary to subject the particle of fat to be observed to conditions in which it would be affected by no other force except its own molecular stress. For this purpose the fat was raised to a temperature a few degrees above the melting point, and in this condition dropped onto the surface of ice or water cooled to a degree which would enable it to fix the thin film of fat before it could recoil into a spheroid state.

The diameter of these fat disks should be about 1.5 centimeters, and each of them should weigh about 200 milligrams.

To free these disks from all external force I submerge them in a mixture of alcohol and distilled water, each recently boiled, to free it of all air bubbles.

The distilled water is first poured into a large test-tube until it is one-third full. The alcohol is now added, pouring it in rather carefully until the tube is nearly full. After standing for an hour all parts of the liquid are of the same temperature, but the heavy liquid remains at the bottom of the tube. One of the disks of fat prepared as above is now placed in the test-tube. It sinks until it comes to a point where the liquid of the tube is of the same specific gravity as itself, and there remains stationary. (The fat disks are kept on the cold water until they are to be used. They are moved by lifting them with a metallic spatula).

The test-tube is now placed in a tall beaker of water, and the bulb of a delicate thermometer is brought near the disk of fat. (These thermometers should indicate tenths of a degree. They were made especially for this work by Emil Greiner, of New York.) The water in the beaker is now heated very slowly, and constantly stirred either by blowing into the beaker with a rubber bulb, or by a paddle. The thermometer is also gently moved from side to side in order to secure a perfect uniformity of temperature in the liquid in contact with the disk. A thermometer is also placed in the water in the beaker, the temperature of which is not allowed to rise more than 2° above the melting point of the fat. As the temperature approaches the critical point the disk is observed to roll up into a rod, which gradually shortens until the mass becomes a perfect sphere. The movement of the thermometer imparts a rotatory motion to the globule, and thus enables the observer to determine the exact point at which it becomes

a sphere. The rate of the rise of temperature during the last degree should not be greater than two or three tenths of a degree a minute.

By this method agreeing duplicate or triplicate determinations can be made and the melting point of fats be determined with far greater accuracy than by any method heretofore proposed.

Pure butter fat is found by this method to have a melting point of about 33°.5 C.

CHEMICAL ANALYSIS.

Of the chemical methods employed there are only three which have been found reliable by long experience. The first of these consists in the separation and determination of the insoluble acids of the butter or fat under examination. It is generally known as the method of Hehner and Angell, but has undergone many modifications in the hands of different analysts.

The following is a description of this method as practiced in this laboratory:

HEHNER AND ANGELL'S METHOD, MODIFIED.

About 4 to 5 grams of filtered fat are weighed into a patent rubber stoppered bottle, by means of a pipette and weighing bottle, and 50 cubic centimeters of an approximately semi-normal alcoholic potash solution added. Duplicate blanks, *i. e.*, alcoholic potash without any fat, are also measured out and all placed in the water-bath. When saponification is complete they are taken off, cooled down, and the contents run into large Erlenmeyer flasks of 300 to 400 cubic centimeters capacity, the liquid adhering to the bottle being rinsed into the flask with small successive portions of boiling water. The flasks are placed on the steam-bath and the alcohol evaporated. Then the amount of semi-normal acid required to set free the fatty acids is ascertained by titrating the blanks. Afterwards about 1 cubic centimeter more than this amount of acid is run into the flask containing the sample, which is fitted with a cork furnished with a glass tube about 1 meter long. It is then heated on the bath until the fatty acids form a clear stratum on the surface of the liquid, when it is removed, cooled with ice water as rapidly as is consistent with the safety of the flask, the tube rinsed out, and the contents carefully poured off from the cake of solidified acid through a dry filter into a liter flask. After being rinsed with a little cold water, about 20 cubic centimeters of boiling water is poured in on the cake, the cork and tube replaced, the contents thoroughly agitated with a circular movement, so as not to get any of the contents on the cork, and the flask again placed on the bath. When heated to the full temperature of the bath it is taken off again, shaken well, and cooled and filtered as before. This washing is repeated three times, using in all about 600 to 700 cubic centimeters of water, when the filtrate is made up to 1 liter, an aliquot part taken and titrated with deci-normal soda. The excess of semi-normal acid used in separating the fatty acids is deducted, and the remainder calculated as butyric acid.

The flask containing the insoluble acids is carefully inverted on a stand, and allowed to dry for twenty-four hours in the air, together with the filter paper, the funnel-shaped neck of the Erlenmeyer flask preventing the cake of acid from dropping out. The paper and flask being quite dry, so that the acid does not stick to them, the cake in

the flask is broken up with a glass rod and allowed to drop into a weighed dish, together with whatever is readily detached from the filter paper. The funnel with the filter paper is then placed in the flask, a hole made in the point of the paper, and the remaining particles washed into the flask with absolute alcohol delivered from a small wash bottle. After dissolving up all the particles left in the flask by the same solvent, it is poured into the dish containing the rest of the insoluble acid, and the flask rinsed out with another small portion of absolute alcohol. This dissolves the fatty acids nearly as rapidly as ether, and is not so volatile, besides serving the purpose of aiding in driving off the water from the acids, when drying. The dish is now placed in a steam-jacketed air bath and kept at a temperature of 100° C. for about 2 hours after the alcohol has been all driven off. After cooling and weighing, it is again dried for two hours longer. If not over 10 to 15 milligrams have been lost it is not dried further; otherwise it is dried for another hour. The dish is then weighed, the original weight of the dish subtracted, and the percentage of insoluble acid determined by dividing its weight by the weight of the fat taken. The percentage of insoluble acid in a pure butter is about 88. In some rare samples it may reach 89, but in such a case there are grave grounds for suspicion. Lards, tallows, &c., on the contrary, have from 92 to 94 of insoluble acid.

The second chemical method in use is known as

KOETTSTORFER'S PROCESS.

About 2.5 grams butter fat (filtered and free from water) are weighed into a patent rubber-stoppered bottle, and 25 cubic centimeters approximately semi-normal alcoholic potash added. The exact amount taken is determined by weighing a small pipette with the beaker of fat, running the fat into the bottle from the pipette, and weighing beaker and pipette again. The alcoholic potash is measured always in the same pipette and uniformity further insured by always allowing it to drain the same length of time (30 seconds). The bottle is then placed in the steam bath, together with a blank, containing no fat. After saponification is complete and the bottles cooled down, the contents are titrated with accurately semi-normal hydrochloric acid, using phenolphthalein as an indicator. The number of cubic centimeters of the acid used for the sample, deducted from the number required for the blank, gives the number of cubic centimeters which combines with the fat, and the saturation equivalent is calculated by the following formula, in which W equals the weight of fat taken in milligrams, and N the number of cubic centimeters which has combined with the fat:

$$\text{Sat. Equiv.} = \frac{2\,W}{N}$$

For pure butters the mean value of N is about 17 when 2.5 grams of butter fat are taken, and the saturation equivalent may vary from 230 to 255. On the other hand, for lards, tallows, and other fats commonly used for adulterants the equivalent rises to 270 to 290. These numbers, therefore, give a fair idea of the purity of a butter, or, if an adulteration has been practiced, of its extent.

The third chemical process used has for its object the determination of the volatile acids present in a fat. Although not an absolute method, yet it has met with great favor among analysts.

REICHERT'S METHOD, AS EMPLOYED IN THE DIVISION LABORATORY.

About 2.5 grams of filtered fat are weighed into a rubber-stoppered bottle, as in the previous methods, 25 cubic centimeters approximately seminomal alcoholic potash added, and the bottle heated on the water bath until the fat is saponified. It is then rinsed with boiling water into an evaporating dish and the alcohol evaporated. The residual mixture of soap and alkali is dissoved in 25 cubic centimeters water, which is poured into a flask of about 200 cubic centimeters capacity, and the dish is rinsed out with another portion of 25 cubic centimeters water, and this also added to the contents of the flask, 20 cubic centimeters of a 10 per cent. solution of phosphoric acid (specific gravity 1.07) are added to separate the acid, the flask fitted to a condenser, and the volatile acids distilled off. When 50 cubic centimeters have distilled over, the process is stopped and the distillate titrated with deci-normal soda.

To prevent the liquid from carrying over non-volatile acid mechanically, the tube which connects it with the condenser runs up straight about 12 to 16 centimeters above the flask before it bends, and is also enlarged into a bulb, which is filled with broken glass or glass wool. A coil of platinum wire is placed in the flask to prevent bumping, and the distillation is carried on at a sufficiently low temperature to avoid violent ebullition. The total quantity of soluble acid in a pure butter amounts to about 5 per cent. It may rise to 6 or sink to 4 per cent. in some cases.

In conclusion, I will say that with the aid of all the methods mentioned on the preceding pages the chemist is reasonably certain of being able to distinguish a pure from an adulterated butter.

It appears further that the microscope with polarized light affords one of the best means of qualitatively examining a butter for impurities when the samples are fresh, while the estimation of the extent to which an adulteration has been carried is best discovered by determining the specific gravity and melting point of the fat, and by subjecting it to the chemical processes just described.

SIMPLE QUALITATIVE TEST FOR ARTIFICIAL BUTTER.

The quantity of stearin in cow butter is small compared with that in lard, tallow, &c. On this difference of constitution Professor Scheffer (Pharm. Rundsch., 1886, 4, 248) has based a method of analysis. A mixture is made containing forty volumes of rectified amyl alcohol and sixty volumes of ether of .725 specific gravity at 15° C. One gram of butter fat is dissolved by 3 cubic centimeters of this mixture at 26° to 28° C. On the other hand, 1 gram of lard required 16 cubic centimeters of the solvent, 1 gram of tallow 50 cubic centimeters, and 1 gram of stearin 350 cubic centimeters.

For the experiment take a test tube of 12 cubic centimeters capacity and place in it 1 gram fat, add 3 cubic centimeters of the fusel-oil ether mixture. After tightly corking the tube put it in a water bath at 18° C. and with frequent shaking bring the temperature to 28° C. If the butter is pure the solution becomes perfectly clear at this temperature. If not clear, more of the solution can be run in out of a burette, and the additional quantity required will be some indication of the quantity or quality of the adulterant which has been used.

According to Scheffer, mixtures of pure butter and lard gave the following data:

Butter.	Lard.	Quantity of mixture required.
Gram.	*Gram.*	*C. centim.*
1.0	....	3.0
.9	.1	3.9
.8	.2	4.8
.7	.3	5.7
.6	.4	6.5
.1	.9	14.4

A trial of this method has shown that it is capable of giving valuable qualitative indications in respect of the purity of the sample under examination.

The best method to secure a sensibly uniform weight of fats is to melt them and measure out from a pipette one cubic centimeter of each. The fats which do not melt easily should be stirred up thoroughly with a wire, while the temperature is raised from 18 to 28° C.

ANALYSES OF BUTTERS AND BUTTER SUBSTITUTES.

In the following tables are found the analyses of—

(1) Butters which are shown by the analyses to be genuine.

(2) Butters which are doubtful on account of low specific gravity and a low amount of soluble acid.

(3) Oleomargarines, butterines, oils, and lards.

The following methods of analyses, not already described, were employed:

SPECIFIC GRAVITY.

Preparation of the sample.

About half a pound of the butter is melted in a dry beaker in the water bath, stirred occasionally, and when the whole has melted and the water and curd have settled to the bottom the clear fat is poured on a ribbed filter in a jacketed funnel. If the filtrate is not perfectly clear and bright it must be refiltered after being reheated. A temperature of 45° to 50° C. will be found most suitable to effect the melting; a higher temperature should be avoided, as otherwise the density may be largely increased. For this reason the fat is kept in a melted condition as short a time as possible.

DETERMINATION OF THE SPECIFIC GRAVITY.

The filtered fat is melted on the water bath at 45° C. and poured into an ordinary 25-cubic-centimeter specific-gravity bottle. The bottle, with its contents, is then placed in a shallow glass dish full of warm water and kept at the temperature of 40° C. for ten minutes. The water in the dish should be nearly on a level with the top of the bottle. The bottle is kept full by the addition of more fat if necessary. At the end of the specified time the stopper is inserted, the excess of fat wiped off, and the bottle withdrawn from the bath, wiped thoroughly, and allowed to cool before weighing. The increase in weight is equal to the

weight of the fat, and this divided by the weight of an equal volume of water at the same temperature will give the specific gravity.

If a specific-gravity bottle with a thermometer stopper, is used, the temperature is obtained more readily, as the bottle is withdrawn from the bath as soon as the desired temperature is observed.

DETERMINATION OF THE SALT.

Weigh out 5 grams of the butter in a tared beaker, melt and pour into a bulb-separating funnel, and wash out beaker thoroughly with boiling water. Shake funnel and contents and allow to stand and settle. Run off the water and repeat treatment with about 50 cubic centimeters boiling water. From 4 to 5 washings will remove all traces of the salt. The solution is then titrated with a standard solution of silver nitrate, using a few drops of a saturated solution of potassium chromate as an indicator. From the number of cubic centimeters of silver solution used it is easy to calculate the amount of salt contained in the butter.

Analyses of butter substitutes.

Serial number.	Articles.	Specific gravity at 40° C.	Water.	Insoluble acid.	Soluble acid by washing out.	Soluble acid by distillation.	Salt.	Ash.	Albuminoids.	Curd.	Koettstorfer's equivalent.	Volume $\frac{n}{10}$ soda for 2.5 grams.
			P. ct.	*Per ct.*	*P. ct.*	*P. ct.*	*P. ct,*	*P. ct.*	*P. ct.*	*P. ct*		
1750	Lard	.90538	0.08	92.59	0.41	0.08	0.00	0.00	.0875	trace	294.30	.20
1751	Beef suet	.90158	0.25	92.59	0.22	0.04	0.00	0.00	......	.00	296.90	.10
1753	Oleomargarine	.90490	9.34	93.59	0.12	0.25	3.64	3.66	.3500	.63	274.00	.70
1754	Neutral lard	.90369	7.42	90.00	0.20	0.10	0.40	0.00	......	.02	270.50	.30
1755	Creamery butterine*	.90569	11.69	92.90	1.16	1.53	2.39	2.71	.3063	.74	274.80	4.30
1756	Oleo fat†	.90287	14.23	93.35	0.10	0.08	0.97	1.07	......	.60	286.20	.20
1787	Country print	.90561	14.45	93.72	0.09	......	2.42	2.35	.8750	1.82	281.10	1.90

*40 per cent. butter fat, 15 per cent. oleo fat, 30 per cent. neutral lard.
†Average, 40 pounds per fat steer.

*Analyses of doubtful butters.**

Serial number.	Specific gravity at 40° C.	Water.	Insoluble acid.	Soluble acid by washing out.	Soluble acid by distillation.	Salt.	Ash.	Albuminoids.	Curd.	Koettstorfer's equivalent.	Volume $\frac{n}{10}$ soda for 2.5 grams.
		Per ct.	*Per ct.*	*P. ct.*	*P. ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*P. ct.*		
1748	.90968	7.45	89.45	3.61	4.60	2.64	2.69	.7443	1.41	252.80	13.10
1757	.90964	11.30	89.44	3.54	4.25	5.28	5.34	.5688	1.63	253.60	12.10
1758	.90987	12.12	87.60	4.71	4.54	0.00	0.12	.4375	.93	251.50	12.90
1767	.90974	10.90	88.68	4.73	4.45	2.16	2.29	.4813	1.33	249.70	12.60
1774	.90972	29.84	87.82	4.84	4.27	0.00	0.12	.9625	1.86	260.10	12.10
1779	.90947	11.59	88.01	3.16	......	5.00	5.00	.8750	1.56	250.60	12.50
1780	.90964	10.06	88.42	3.02	......	5.40	5.66	.8750	1.58	250.70	11.60
1793	.90938	8.50	88.00	3.34	......	13.00	13.08	....	1.12	253.50	12.30
1794	.90965	9.06	88.50	3.44	......	2.84	3.43	.4375	.98	252.00	11.70

*These samples were bought for pure butter.

Analyses of butter.

Serial number.	Specific gravity at 40° C.	Water.	Insoluble acid.	Soluble acid by washing out.	Soluble acid by distillation.	Salt.	Ash.	Albuminoids.	Curd.	Koettstorfer's equivalent.	Volume $\frac{n}{10}$ soda for 2.5 grams.
		Pr. ct.	*Pr. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*		
1742	.91046	13.33	88.64	4.01	4.50	2.84	......	.7875	1.46	254.20	12.50
1743	.91119	8.53	87.85	4.14	4.57	3.69	3.43	.8312	1.31	250.60	13.10
1744	.91032	8.57	88.65	3.52	4.78	2.81	2.97	.8750	1.30	268.50	13.50
1745	.91067	8.14	88.08	3.68	5.48	2.04	2.02	.5688	1.25	264.90	15.30
1746	.91029	16.82	88.91	3.00	4.56	3.79	3.97	.7438	1.56	252.70	12.90
1747	.91244	4.59	86.60	5.02	5.51	3.41	2.97	.5250	0.83	244.30	15.60
1749	.91165	11.46	87.50	5.49	4.61	1.48	1.55	.8312	1.14	250.10	13.10
1752	.91004	17.38	88.07	3.70	4.54	0.00	0.06	.4375	0.68	238.60	12.80
1759	.91013	13.95	87.47	4.73	4.80	0.00	0.07	.4375	0.81	249.70	13.60
1760	.91063	22.12	87.84	4.98	4.70	0.00	0.06	.1750	0.49	248.70	13.40
1761	.91067	23.46	87.47	5.27	4.99	0.00	0.05	.1750	0.59	243.00	14.10
1762	.91089	21.62	87.38	5.15	4.93	0.00	0.00	.2188	1.01	248.80	14.00
1763	.91073	11.89	87.71	4.69	4.98	2.61	2.84	.2625	1.30	244.90	14.10
1764	.91155	21.96	86.65	5.34	4.74	0.00	0.11	.4375	1.21	244.00	13.20
1765	.90958	31.55	88.09	4.45	5.02	0.57	0.13	.6125	1.83	252.00	14.30
1766	.91042	11.17	....	5.31	4.52	2.56	2.45	.4375	1.11	247.00	12.80
1768	.90995	7.68	87.24	5.08	5.21	5.62	5.61	.2625	0.71	247.00	14.80
1769	.91183	9.68	87.30	5.94	5.05	4.09	4.41	.5230	1.37	244.10	14.30
1770	.91069	7.35	88.14	5.05	4.47	5.28	5.16	.4375	0.91	252.10	12.70
1771	.91079	12.28	87.60	5.37	4.93	3.69	4.37	.4813	1.08	246.40	14.00
1772	,91093	8.89	87.21	5.47	5.26	3.18	3.49	.3063	1.03	245.10	14.90
1773	.91064	18.75	86.68	4.75	4.03	0.00	0.13	.7000	1.41	260.70	11.40
1775	.91034	9.87	87.58	5.17	4.56	4.83	5.51	.4375	1.12	251.80	12.90
1776	.91239	10.84	86.61	5.42	4.45	3.12	2.48	.4375	0.97	250.90	12.70
1777	.91031	12.28	88.48	4.66	3.92	5.79	6.20	.7438	1.43	236.50	11.10
1781	.91010	7.26	....	3.97	......	6.42	6.53	.4375	1.43	247.10	13.20
1782	.91112	12.30	87.23	4.24	......	6.53	6.76	.5250	2.02	245.40	13.60
1783	.91082	6.93	87.59	3.92	......	3.92	3.99	.5250	1.33	248.40	12.50
1785	.91186	8.29	87.10	4.48	......	5.11	4.71	.4375	1.16	247.50	14.50
1789	.91061	8.44	87.73	3.91	......	3.15	4.73	.7000	1.42	246.60	12.60
1790	.91080	4.44	87.85	4.41	.....	1.81	2.24	.7000	1.02	251.50	13.90
1792	.91106	13.67	88.25	3.47	......	7.10	7.56	.4375	3.10	240.20	12.30
1795	.91136	8.22	87.75	4.18	......	4.37	4.79	.5125	1.34	240.70	14.50
1798	.91066	....	....	......	......	1.76	......	......	......	....	12.93

ESTIMATION OF FAT IN MILK.

The percentage of fat in milk is one of the best indications of the presence or absence of added water. Various methods of speedily and accurately estimating the percentage of fat have been proposed. One of the most successful of these is known as Soxhlet's areometric method. The principle of this method is based on the fact that if the milk first be rendered slightly alkaline and then shaken with ether the fat passes into solution, and when the mixture is allowed to rest for some time the etherial solution of the fat will collect at the top. The specific gravity of this solution will vary according to the content of fat which it contains, and by the determination of this specific gravity the percentage of fat is determined.

The great objection to the use of this method is found in the difficulty with which the ethereal fat solution separates. Various theories have been proposed to account for this peculiarity of milk in refusing to allow the ether solution to separate. Caldwell and Parr have supposed it to be due to the bran in the cow's food; Liebermann ascribes it to failure of manipulation; Schmœger, that it is caused by the milk standing on ice; Soxhlet thinks it is the result of deficiency of fat; and others attribute it to differences in age and breed of the cows.

Therefore the method, in order to be of general application, must be subjected to some radical modification. In this direction were the attempts to secure a more prompt separation by varying the amounts of caustic potash solution employed. These attempts, as the record

has shown, were entirely unsuccessful. Even if the different kinds of milk would permit a prompt separation by varying the quantities of alkali employed, the amount for each sample could only be determined by numerous and tedious experiments.

I therefore turned my attention in another direction. It seemed to me that a centrifugal machine might be used to secure this separation, and accordingly I had a cast-away drug-mill, formerly used in the laboratory, modified so as to serve for this purpose. The machine was so arranged as to hold four separatory flasks and impart to them a high speed of rotation.

At this point of my investigations this apparatus was finished, and I immediately subjected it to a trial.

Four samples, which had not separated at all at the end of 3 hours, were placed in the apparatus and whirled for 10 minutes. At the end of this time 3 of them had completely separated and the fourth nearly so. The apparatus was set in motion again for 5 minutes, at the end of which time the separation of the fourth sample was accomplished.

The number of revolutions per minute of the machine was about 250.

It will be seen from the above that the very first trial of the machine was completely successful, securing a perfect separation of the ether-fat solution in a few moments in samples which previous trial by the usual method had failed to separate in several hours.

The next determinations were made on a sample of milk purchased at the Department restaurant.

Duplicate flasks were treated in the usual way to secure the separation, and only at the end of 2½ hours was enough clear solution obtained to get a reading: No. 1 gave 2.40 per cent. fat; No. 2 gave 2.30 per cent. fat.

The first set of samples of the same milk separated by the centrifugal gave the percentages below: No. 1 gave 2.52 per cent.; No. 2 gave 2.32 per cent. fat.

The separation took place perfectly in 10 minutes with a rate of revolution of about 300 per minute.

The second set of 4 samples was treated in the same way and separated completely in 8 minutes. The following readings were obtained: No. 1 gave 2.36 per cent. fat; No. 2 gave 2.34 per cent. fat; No. 3 gave 2.31 per cent. fat; No. 4 gave 2.30 per cent. fat.

The third set of samples separated by the centrifugal showed the following percentages: No. 1 gave 2.23 per cent. fat; No. 2 gave 2.30 per cent. fat.

The volume of the clear ether-fat solution in each case was about 40 cubic centimeters.

The next trial was with milk also purchased in the Department restaurant. It proved to be one of the rare cases in which a reasonably prompt separation was secured by the old method. After 30 minutes about 25 cubic centimeters of the ether solution had separated, which was enough to get a reading. Duplicate determinations were made: No. 1 gave 2.08 per cent. fat; No. 2 gave 2.04 per cent. fat.

Four separations of the same milk were also made with the centrifugal. Separation took place promptly in 8 minutes at a speed of about 300 revolutions per minute, and the volume of ether fat in each case was about 40 cubic centimeters: No. 1 gave 2.01 per cent. fat; No. 2 gave 2.01 per cent. fat; No. 3 gave 2.00 per cent. fat; No.

No. 4 gave 2.04 per cent. fat; which is an agreement as close as any one could expect.

Having thus shown that the centrifugal method was capable of making the areometric method applicable to almost every sample of milk, I undertook a new series of experiments. In all 155 samples were subjected to treatment.

Of the 155 samples examined only 57 gave a good separation by the Soxhlet method in 30 minutes. Of the remaining 98 about half did not separate at all so as to permit a reading, and the other half only after several hours. Compare this with the centrifugal method, in which only 6 samples out of the whole lot required over 15 minutes for separation and only 1 was abandoned as entirely inseparable, and the more general application of the process is at once apparent.

Of the 6 samples mentioned above 3 were from the same cow, a grade short-horn, 4 years old, weight about 800 pounds, in milk since July, 1885. She gave 6 quarts of milk a day; was milked at 5 a. m. and 5 p. m. The samples of milk sent were taken at 5 p. m. on April 13, 17, 23, 1886, respectively. The food received by this cow was the same as for all the others (36) from which samples were taken for analysis. They received at 5 a. m. 3 pounds of wheat bran and the same of hominy chops, and then as much corn (maize) fodder as they could eat. The bran and chops were fed dry. In pleasant weather the cows were out until 3 p. m. They were then fed 10 pounds each of unthrashed oats. At 5 p. m. they got a half peck of chopped turnips and a repetition of the morning's feed of bran and chops.

The hominy chops used showed on analysis the following composition:

	Per cent.
Water	7.13
Ash	2.53
Ether extract or fat	9.03
Carbohydrates	69.32
Crude fiber	2.36
Albuminoids	9.63

Two of the other samples were received April 27 and 30 from a thoroughbred Jersey, 4 years old, weight about 600 pounds, in milk since July 1, 1885, giving at the time about 5 quarts daily. On the 29th of April samples of milk were also treated from the same cow, but after dilution the centrifugal separation, although more than usually difficult, did not require so long a time as on the occasion mentioned.

There is nothing shown by the analysis, by the breed of cow, nor by the food which gives any definite idea of the cause of the peculiarity in these milks which does not permit a speedy separation. It certainly is not the quantity of fat present, for other milks having the same, more or less, amounts of fat separated without difficulty.

In all, 90 samples were compared by the usual method of separation and by the centrifugal. By the former method the mean percentage of fat obtained was 4.01, and by the latter 3.88. It thus appears that the numbers obtained by the centrifugal method must be increased by .13 in order to correspond to those of the old method. This discrepancy is readily explained when it is remembered that by the centrifugal motion the percentage of ether left in the emulsion would naturally be less than with the former process of separation. The ether-fat solution thus becomes more dilute, and consequently has a lower specific gravity. When, therefore, the percentage of fat in a milk determined areometrically is calculated by the tables given

for the old method of separation, it should be increased by .13 in order to represent the actual quantity present.

I think it safe to conclude, from the data which have been obtained, first, that the method of Soxhlet cannot be applied to the determination of fat in American milks, especially if they be from individual animals. It works somewhat better on mixed milks from a large dairy, but even in this case it is a rare thing to secure a prompt separation, and in most cases the method would be very difficult of application.

Second. That by the use of the centrifugal machine described a prompt separation of the ether-fat solution can be obtained in all cases, even in those in which after 48 hours no separation whatever takes place by the usual method.

Third. That the estimation of the fat in milk by Soxhlet's areometer can only be accurately secured when standard volumes of aqueous ether and caustic potash are employed, when the volume of the ether-fat solution separated is sensibly constant, and the time employed in separation sensibly the same. These conditions can only be secured by the use of the centrifugal machine described.

I propose to use a centrifugal apparatus also for assisting in the separation of the ether-fat solution in the lactobutyrometer; and it has already proved its usefulness in separating precipitates which subside very slowly.

I am of the opinion that such a machine would prove of great value in every chemical laboratory aside from its utility in determining the fats in milk.

The process just mentioned was first used in May, 1885, at the Department of Agriculture, and a full description of it was given at Buffalo in August, 1886, before the chemical section of the Association for the Advancement of Science.

A machine resembling this has lately been patented in Germany by Laval under the name of *Lactokrit*. The disk of this machine is so arranged as to be capable of a high rate of revolution, viz, 6,000 per minute.

The milk in which the fat is to be estimated is first treated with an equal volume of a mixture of 20 parts concentrated citric acid and 1 part of sulphurous acid. After shaking, the test-tube containing the milk mixture is warmed to 30° C., or above, and the tubes which fit into the revolving disk are filled with the mixture and put in position. The temperature of the tubes is kept at 50° C. by means of a bath of hot water.

In 5 minutes the fat is separated, and the percentage thereof read off by the graduations on the tubes containing it. (*Chem. Centralblatt*, No. 42, October, 1886, pp. 797 *et seq.*)

ADAMS METHOD FOR THE GRAVIMETRIC ESTIMATION OF FAT IN MILK.

This method was first described in *The Analyst*, Volume 10, pp. 46 and following. Five cubic centimeters of the milk are placed on a strip of blotting or filtering paper, previously exhausted with ether, and rapidly dried. The paper may be cut into strips 2 inches wide and 20 inches long. After the drying is complete the strip of paper is rolled into a coil and extracted in a Soxhlet apparatus with ether. This method has been proved by careful experiment to be very exact, and gives a slightly higher percentage of fat than any other gravimetric method heretofore proposed.

ADULTERATION OF SPICES AND CONDIMENTS.

BY CLIFFORD RICHARDSON.

The class of substances, including mustard, pepper, cayenne and chillis, ginger, cloves, nutmeg and mace, cinnamon and cassia, and allspice, which are commonly designated as spices and condiments in the discussion of foods and dietaries, are probably more largely subject to adulteration and with less attempt at concealment than any of the foods proper. Fortunately the sophistication is simply the addition of material of a harmless nature for the purpose of diluting the more expensive spices and making it possible to reduce the price in accordance with the demands of the dealer and eventually the consumer.

These substances were originally luxuries and not regarded as an essential part of the diet of even the richer classes; now the poorest man is not satisfied without them, and pepper is as well known and as much employed as salt. All this has had much to do with the introduction of adulteration as a means of catering to the demands of the lower classes for cheap spices, and increasing step by step its extent until the adulteration has become so gross in many cases as to expose itself or bring about the enactment of laws for the repression of the sale of such substances. At the present time in several of our largest cities the price to be paid for a spice is named by the retail dealers, and he is then supplied from the spice-mill with a mixture containing the largest amount of pure material which can be supplied for the money, the necessary weight being made up of diluents of some cheap but harmless substance. As an example, the fact that a New York firm in a short time used and put into the market in their spices more than 5,000 pounds of cocoanut shells shows how far the custom has been carried, and it is easy to see how difficult it would be to bring this state of things to an end without some governmental action, it being improbable that by any means of agreement among themselves the grinders of spices could unite in doing away with the practice, or that any education of the masses would teach them to refuse to purchase a ground spice at a price which is far below that of the unground article.

This alone, the relation between the prices of ground and unground spices, is often sufficient to point out the fact that a ground spice must be largely diluted, and on the other hand, when purchasing from a reliable dealer, a slight increase in cost over that of the spice in its original form is evidence of the purity of the powder. Those who desire pure ground spices can always obtain them by paying their value; they are by no means uncommon in the market, but as long as there are those who do not know that it is for their interest to buy the best rather than a cheap article for its low price, such people must suffer or be protected by legal enactments, which shall prevent and prohibit the existence of such mixtures. Until this is done the supply of a demand which certainly exists may be considered to be at the least justifiable on the part of the spice millers, and education of those ignorant of the state of the trade must be the preliminary to legislation upon the subject. When proper legislation has found a place on the statute-books the manufacturers will find themselves in a position where, without detriment to themselves, they can all unite in giving up the practice.

Under the laws for the prevention of the adulteration of foods, which have been in operation in Germany, England, France, Canada, and a few of our states during a longer or shorter period of time, a large share of attention has been given to the adulteration of spices and condiments and the means of detecting them. Fortunately the latter are not difficult, and the results have been an awakening of the communities in these countries to an appreciation of the advantages of pure spices and the placing of the method of detection on a more certain basis.

EXPERIENCE IN COUNTRIES HAVING PUBLIC ANALYSTS.

In England the public mind had been so far educated by the publications of private investigators, such as Hassall, that in 1860 laws were passed for the prevention of the adulteration of food and drink. These have been repealed and modified, so that the present law dates from 1875 and amendments of 1879.

Unfortunately there is no government report upon the results of the scientific work done by those employed under the act, and we are indebted to the Society of Public Analysts for a large portion of the information which is at our disposal in regard to adulteration in England. We have also in the publications of Hassall, Blyth, and Allen volumes which give the most recent scientific data as to the best method for the detection of adulteration and illustrations of the forms in which foreign matter occurs. On Dr. Hassall's work is founded many of our present methods of examining foods microscopically, and especially spices and condiments. In *The Analyst*, the publication of the Society of Public Analysts, will be found, in the proceedings of the society, in papers of individuals, and in reports of prosecutions, much information in regard to the status of adulteration in England during the last eleven years, including the material used for adulteration of spices and the means of detecting it. The lack of an official publication of the results and all that has been done, both in regard to particular samples and methods employed for their examination, is, however, much to be regretted. There is the same difficulty in Germany. The law of the Empire of 1881 provides for the prevention of the adulteration of the substances which we have under consideration, but no reports on the execution of the law or of the results, scientific or otherwise, have been available to us. Much, however, has been published in the technical and scientific journals on the method of detecting adulterants which is of the greatest value.

In France the laboratory of the prefecture of police of Paris, which has control of the investigation of the food supplies of that city, makes an elaborate report annually, of which, however, but a small portion is devoted to spices, although they are recognized as being largely adulterated; pepper, for example, being mixed to an astonishing extent with ground olive-stones. Other cities of France have municipal laboratories, whose reports, if any there are, have not reached us.

In this country Canada makes a much better statement of the results which have followed the enforcement of the adulteration of food act of 1876 than is done anywhere else. The commissioner of inland revenue has published annually a statement showing the entire number of samples analyzed, the persons supplying them, and their composition and adulterants. Spices occupy a prominent position in the

reports, and a collation of the results of the investigations of the several public analysists is of interest. In 1878, when the reports first became available to us for reference, the summary of the spices analyzed showed:

Articles.	Unadulterated.	Adulterated.	Adulterated.
			P. ct.
Allspice	1	11	92.5
Cassia	2	2	50.0
Cloves	3	15	83.3
Cinnamon	3	6	66.6
Ginger	5	8	61.5
Mustard	....	38	100.0
Pepper	12	28	70.0

This enormous amount of adulteration, amounting to nearly a universal custom, was followed in 1879 by a similar report:

Articles.	Unadulterated.	Adulterated.	Adulterated.
			P. ct.
Allspice	6	10	62.5
Cassia	....	1	......
Cloves	7	9	56.2
Cinnamon	3	16	84.2
Ginger	5	6	55.5
Mace	5	1	16.6
Mustard	3	....	......
Pepper	22	21	48.8

In 1880 there were reported, as the results of the public analysts' work:

Articles.	Unadulterated.	Adulterated.	Adulterated.
			P. ct.
Allspice	15	6	31.6
Cloves	12	10	45.5
Cinnamon	6	16	72.7
Ginger	9	8	47.1
Mustard	....	16	100.0
Pepper	24	18	42.9

There is a very slight improvement apparent, but it must be remembered that in examinations of this description the specimens selected are always of a suspicious nature, those which are already known to be pure being omitted, so that year by year the list of brands which are excluded from examination increases.

In 1881 and the following years the results were tabulated as follows:

Articles.	1881.		1882.		1883.		1884.		1885.	
	Genuine.	Adulterated.	Genuine.	Adulterated.	Genuine.	Adulterated.	Genuine.	Adulterated.	Genuine.	Adulterated.
Allspice	8	17								
Cloves	6	7							12	10
Cinnamon or cassia	12	12								
Ginger	7	5	7	16					37	29
Mace	1	1								
Mustard	2	2							11	*39
Nutmeg	1									
Pepper	16	29	14	28					31	29
Cayenne									13	11
Spices	53	73	34	32	48	86	38	112	103	118

*Many labeled "Mixtures."

It is seen that several years after the enactment of the law the adulteration of spices is as enormous as at first. This arises, however from lack of prosecution and non-enforcement of the law. Of the occurrence of adulterants in spices the chief analyst says in his report for 1885:

During the year considerable attention was paid to spices and condiments. Viewing the fact that in the past a very large amount of adulteration had been reported as prevailing in these substances, and with a view to ascertaining whether the adulteration was practiced by the manufacturer or by the dealers, a systematic visitation was made of all the spice-grinders in the Dominion (or all that could be recognized as such), and their factories and stores were inspected, under sections 7 and 8, with the results as shown in the appendix.

The examination of 19 samples of ground cinnamon resulted in finding 7 genuine, 4 consisted of a substitution of cassia; 1 was adulterated with cassia, and 6 with other inert matter; 1 consisted of cassia adulterated with foreign vegetable matter.

Of ground cloves, 22 samples were examined. Twelve proved to be pure and 10 adulterated, the adulterant chiefly used being clove stems, pea meal, roasted and ground cocoanut shells.

Of 66 samples of ground ginger, 29 were reported as being adulterated, almost exclusively with wheat flour, non-injurious to health, doubtless; but unless the purchaser be duly warned of the nature of the compound his pocket would be seriously prejudiced, if not injured, as this sophistication was practiced to the extent of from 10 to 15 to from 25 to 40 per cent., the pungency being imparted by the judicious admixture of Cayenne pepper.

Fifty samples of mustard were examined, and many of these were properly sold as "compound" or mixtures, but one of the worst samples was sold with a label guaranteeing it to be "ground from finest English seed and free from adulteration." Of the 50 samples, 9 were reported genuine, 2 of excellent quality, and 39 were all more or less admixtures of mustard-seed or mustard cake (from which the natural fixed oil had been expressed), with wheat flour and turmeric, and in some cases with corn-starch or bean meal, in varying proportions up to as high as 50 or even 60 per cent. It was formerly contended that the addition of wheat flour or other inert matter was a necessity, to give the ground mustard keeping qualities and make the condiment palatable by softening its natural acridity. But the most reputable manufacturers have demonstrated the fallacy of this contention by the production of an absolutely pure mustard, which has received public acceptance and appreciation; and two, at least, of our home manufacturers are happily following in their steps. It is a question yet to be decided how far the use of mustard cake, deprived of the natural fixed oil, is permissible in the manufacture of this condiment. Dr. Ellis's observations on this matter are very much to the point, and have received confirmation by similar experiments in my laboratory, and doubtless when next the analysts meet in conference this question will be settled in a manner favorable to the use of mustard cake.

Twenty-four samples of Cayenne pepper were examined, of which 14 were reported adultered, but 3 of these were appealed to the judgment of the chief analyst, and the decision of the public analyst was not sustained, as will be seen on

reference to "appeal cases." The remaining 10 were reported adulterated with wheat flour and colored earth, in one case to the extent of 50 per cent. The other 10 samples were reported unadulterated, save 1, which was doubtful, it apparently having been artificially dressed with a fixed oil.

Sixty samples of ground pepper, black and white, were examined, of which 31 are reported as unadulterated, 1 doubtful, and 28 all more or less adulterated, the generality of them to the extent of from 10 to 20 per cent., but the more flagrant cases from 30 up to even 75 per cent. in one case. The adulterant is chiefly farinaceous matter, also mustard husk, pepper hulls, clay, sand, and, not the least conspicuous, ground cocoanut shells—doubtless an innocent admixture, so far as health is concerned, but decidedly not a material of a character to improve the flavor or value of the pepper as a condiment.

As stated, these samples of spices were all obtained from either the actual producer or wholesale distributer, and the results prove that, whether or not the retail vender still further "improves" his spices, &c., before retailing them, his demand for a cheap adulterated article is amply provided for by the manufacturing dealer.

For the most part the producers of these sophisticated goods expressed themselves anxious for the enforcement of the law for their suppression, but objected to the requirements of the law that if sold they should be distinctly labeled as impure. Some, on the other hand, contended that the public was benefited by a slight admixture; that a really better article could be supplied at a lower price if the finest and freshest spices were ground with an admixture of inert matter than a thoroughly pure article but ground from old or perished spices—a specious contention, utterly untenable in the true interests of the public.

But have not the producers of these sophistications some justification? Is not the supply of a demand which undoubtedly has existed a justifiable enterprise, whatever that demand may be, so long as it is within the law? Ignorance does undoubtedly demand cheapness, and a demand thus ignorantly made is only too surely supplied, and hence the need for costly legislation to protect an ignorant and thoughtless public against itself, for it does demand the very goods which the analyst must condemn and the vender be prosecuted and fined for selling; whereas the public's reckless ignorance is the chief cause, and should suffer some measure of the penalty. It is time that, through the operation of this act, such ignorance should be cleared away and the public be enlightened and awakened to its own true interests.

These remarks apply equally well to much of the spice sold in the United States. Massachusetts, New York, New Jersey, and Michigan alone have laws of any value in regard to the adulteration of food, and it is easy to see in what condition the spices and condiments sold in other parts of the country must be. In Massachusetts, where investigations under the law have been going on since 1882, it has been shown, as in other localities, that the adulterations of spices are numerous but harmless. Dr. Sharpless, in his report of 1882 upon this subject, remarks that he agrees with the opinion expressed by Dr. Leeds, of New Jersey, in his report of 1880, to the New Jersey State Board of Health, that there has been much sensational writing upon the subject. This is perhaps the case with some few writers of that stamp, but it can have done no harm, for it has not produced sufficient effect upon the public to create a demand for any purer spices, as appears from the figures of Dr. E. S. Wood in 1884, who reports in regard to the samples he examined as analyst of foods for Massachusetts:

Articles.	Genuine.	Adulterated.	Adulterated.
			Per cent.
Black pepper	20	44	68.75
White pepper	13	31	70.45
Red pepper	5	0	....
Mustard	29	47	61.84
Ground cloves	0	11	100.00
Cassia	0	2	100.00
Pimento	2	0	....
Ginger	1	0	....

This is nearly as serious a condition as was found in Canada, but again in 1885 Dr. Wood reports:

Articles.	Genuine.	Adulterated.	Compounds.	Adulterated.
				Per cent.
Mustard	31	37	20	64.8
Cloves	15	76	....	83.5
Cassia and cinnamon	48	26	1	36.0
Ginger	55	17	....	23.6
Allspice	30	8	....	21.1
Ground mace	9	9	....	50.0
Black pepper	6	19	3	78.6
White pepper	21	39	....	65.0

which is little or no improvement. He found the common adulterants of mustard to be flour, turmeric, and sometimes a little cayenne. Cloves suffered from extraction of the volatile oil and the addition of clove stems, allspice, burnt shells, and other cheap substances. Cassia contained ground shells and crackers. Ginger was in many cases colored, and in some instances wheat and corn flour and clove stems were present; allspice is too cheap to be often adulterated, but in eight samples mustard hulls, ground shells, clove stems, and cracker dust were found. In mace, flour and corn-meal were diluents, and for the peppers, crackers, mustard hulls, pepper dirt, powdered charcoal, rice, corn, and buckwheat.

Under the New York law of 1881 Prof. S. A. Lattimore investigated a number of spices and spice mixtures submitted to him.

The result of his examination of the commercial ground spices are commented on, after giving the proportions which were found adulterated, in these words:

The spices present an inviting field for the exercise of fraudulent arts. They are almost universally sold in the form of fine powder and in opaque packages, which do not admit of easy examination on the part of the purchaser. Consequently any cheap substance which may be easily pulverized to a similar degree of fineness, and which possesses little distinctive taste or color of its own, answers the purpose; so that the list of adulterants for this class of articles is naturally very large. The adulterations found in the samples now under consideration may be classed into four groups: first, integuments of grains or seeds, such as bran of wheat and buckwheat, hulls of mustard seed, flax seed, &c.; second, farinaceous substances of low price, such as are damaged by the accidents of transportation or long storage, such as middlings of various kinds, corn-meal and stale ship-bread: third, leguminous seeds, as peas and beans, which contribute largely to the profit of the spice mixer; fourth, various articles, chosen with reference to their suitableness for bringing up the mixture as nearly as possible to the required standard of color of the genuine article. Various shades, from light colors to dark browns, may be obtained by the skillful roasting of farinaceous and leguminous substances. A little turmeric goes a great way in imparting the rich yellow hue of real mustard to a pale counterfeit of wheat flour and terra alba, or the defective paleness of artificial black pepper is brought up to the desired tone by the judicious sifting in of a little finely pulverized charcoal. Enough has been already given to show that the field for sophistications of this sort is a wide one, and offers large scope for the development of inventive genius, so that each manufacturer of articles of this class would be likely to possess his own trade secrets. It will be observed that the adulterating materials just mentioned all belong to the class claimed to be harmless. In no instance has any poisonous substance been discovered. The proportion of foreign and genuine substances in the spices varies between wide limits, in some instances the former being slight; in others, the latter seemingly present in just sufficient quantity to impart faintly the requisite taste or odor. Even this small proportion of the professed article is occasionally further diminished by the substitution of other substances; as, for example, in imparting to corn meal finely ground a pungency suggested by real ginger by the additlon of a little salt and red pepper.

It is probably not so widely known as it should be that the demand for the ma-

terials for adulteration has called into existence a branch of manufacturing industry of no insignificant magnitude, having for its sole object the production of articles known as "spice mixtures" or "pepper dust." The use of "pepper dust," or, as the article is commonly designated in the technical language of the trade by its abbreviation "P. D.," is a venerable fraud.

The manufacture of "P. D." is now a regular branch of business, and the original and specific term "pepper dust" has expanded with the progress of inventive art to generic proportions, until now we have as well known articles sold by the barrel, "P. D. pepper," "P. D. ginger," "P. D. cloves," and so on through the whole aromatic list. When it is considered that these imitations, lacking only such flavoring with the genuine article as the dealer thinks necessary to make his goods sell, are sold at at from 3 to 4 cents a pound, and the retail price paid by the consumer is compared with it, the strength of the temptation to engage in such practices is clearly seen. When manufacturers openly advertise themselves as assorters and renovators of merchandise, and openly propose to cleanse musty and damaged beans by a new and patented process, it is full time that its significance should be considered by the public.

From these investigations which have been quoted it appears that the adulterants which are met with in this country are very numerous. Under the head of spice mixtures, or "P. D." much refuse of all descriptions is used up, and there are such changes in the character of the material from time to time as the sources of damaged material or refuse at hand may suggest. The diluents used in Baltimore are quite different from those in New York, and in the District of Columbia, in consequence, some of the adulterants which are mentioned most commonly in the reports from the North are never found. While it is possible, therefore, to give a list of substances which have been used as adulterants, it is quite out of the question to say in what directions the ingenuity of spice mixers will extend in the future. The following contaminations in the various spices have been already noted in this country:

Spices.	Adulterants.
Allspice	*Spent cloves*, clove stems, cracker dust, ground shells.
Cayenne	*Rice flour*, salt, and shipstuff.
Cassia	Ground shells and crackers.
Cinnamon	*Cassia*, peas, starch.
Cloves	*Spent cloves, clove stems*, allspice, roasted shells, wheat flour, peas.
Ginger	*Cereals, turmeric, mustard hulls*, cayenne, peas.
Mace	Cereals or starch, buckwheat.
Mustard	*Cereals and starch*, turmeric, peas.
Nutmeg	Do.
Pepper	*Refuse of all sorts, pepper dust, ground crackers* or *shipstuff, yellow corn, rice, mustard hulls*, charcoal, cocoanut shells, *cayenne*.

The materials in italics have been identified in spices examined in the laboratory of this division, but some of the commonest adulterants have not been found.

Of the means of detection of adulteration, details will be given in a special report of this division (Bulletin No. 13, Part 2), but they are of too technical a nature for reproduction in this place.

It will suffice to repeat what has already been said, that fortunately it is not difficult to detect the presence of adulteration with the means at our command, so that with a proper board of analysts the practice may be prevented under the enforcement of a carefully drawn law.

Microscopical examination alone will in most cases reveal the quality of a ground spice, and when a careful study has been made of the normal character of the various spices and of the usual adulterants,

it is not only easy to detect the presence of foreign matter, but to identify the source. In the peculiar form and properties of the various starches we find a great aid, inasmuch as many of the spices contain no starch, and the presence of any at once shows that some foreign substance containing it has been added. Other spices contain starch, but of such distinctive form and character that it is not easily confused with that of adulterants. The elements of which the structure of the berry, the bark, the pod, or whatever part of the plant may be used as a spice, are composed are also distinctive, and the arrangement of the different kinds of vegetable cells more or less characteristic of each spice and distinct from its adulterants. For all this examination it is of course necessary to have for reference specimens of well-authenticated spices, whole and ground, and of the common starches and adulterants. In our special bulletin an attempt has been made from our own experience and that of others to describe the most characteristic points in the structures which are met with.

Although the microscope is the most convenient and ready means of determining the character of a ground spice, in all cases of importance, where a question of the sale of adulterated articles is involved, resort for confirmation should be had to chemical analysis. Unfortunately, this method of investigation is not as available as the microscope, requiring greater facilities and skill, and consuming much longer time. It has not, in addition, received that amount of attention which it should have done, and in consequence the standards of purity are not as well fixed as they should be.

The results of a study of this side of the subject will be presented in the special bulletin of this division which has been referred to.

Considering the spices individually as they are met with, both pure and in the trade, there are certain peculiarities which should not be overlooked.

MUSTARD.

Mustard, as sold in the ground state, should be the farina or flour of the black or white mustard seed; that is to say, the flour from the interior of the seed, bolted or separated from the hulls. The two kinds of seed, although derived from plants of the same genus, are somewhat different in their chemical composition. The black seed is much the most pungent, and develops on mixing with water a volatile oil which gives this condiment its penetrating character. There is also present in the seed complicated organic substances of a bitter nature, to which is due also some of the peculiar flavor, and while the white seed forms no volatile oil with water, it contains more of this bitter substance. It is, therefore, very common to mix the two in grinding. The sources of the seed are various. In our markets at present there are quoted California black and white, Dutch, Trieste black, and English, the last being the most valuable.

In the manufacture of the seed into flour for the market two customs have arisen which change the nature of the original substance, and therefore would commonly come under the head of adulteration. One is extremely old, the addition of flour for the purpose of making the condiment keep better. This necessitates the restoration of the yellow color by turmeric. Both of these diluents are harmless, but there seems to be no reason for their use, and it is gradually becoming commoner to find mustard free from them in English brands.

The other custom is the abstraction of the fixed oil by pressure be-

fore grinding the seed. The percentage of this oil is over 30. It adds nothing to the flavor of the mustard, probably injures its keeping qualities, makes the seed more difficult to mill, and its removal is therefore a benefit. It is a nearly universal custom at the present day in thiscountry and is not considered as fraudulent by the Canadian analysts.

Falsifications of mustard other than those mentioned are not common. The hulls, bolted from the flour in the process of manufacture, are preserved, and form the basis of the adulteration of many other spices.

PEPPER—BLACK AND WHITE.

Pepper is more in demand than any other spice, and in consequence is more adulterated. Its appearance in the ground form, especially of the black, is such as to make it possible to use all sorts of refuse for this purpose, and almost everything that has been used as an adulterant has been found in pepper. White pepper, which is simply the black deprived of its outer black coats, is of course less easily falsified, but in France is diluted to an immense extent with ground olive stones, which bear a striking resemblance. Among the samples from Washington grocers, pepper sweepings—that is, husks and dirt, rice, cayenne, yellow corn and mustard hulls—were the commonest admixture. Sand is said to be very commonly added abroad, but has not been met with here.

In Canada and New York ground cocoanut shells are a cheap source of adulteration, but they have not extended so far South.

The quality of a ground pepper can be told by an expert from its weight and an examination with a lens of low magnifying power. The particles are not coarsely ground and it is not difficult to pick out pieces of husk, shells, and rice, and, if necessary, a more careful investigation under a microscope of higher power will serve for confirmation. Black peppers, in our experience, are much more liable to adulteration than white, although it is perfectly easy to dilute the latter with broken rice, corn, or beans, which are inexpensive. All these materials fortunately, owing to the grossness of the adulteration, are readily recognized, and there is hardly the necessity for recourse to chemical analysis. There has been, however, considerable investigation in this direction, so that there are means of confirming the optical examination which are of great value. Determination of the amount of starch is one of the methods which is in use, for if under the microscope foreign starch is not detected, then the addition of P. D. or other starch-free adulterants will diminish the percentage found. In this way, too, one is able to arrive at an approximate conclusion as to the proportion of adulterant added, which can only be estimated within wide limits under the microscope. In spite of the immense amount of adulteration it is possible from the best shops to obtain pure ground peppers, but it is at the same time safer, with a family spice-mill, to grind the whole berries as they are needed. The sources of our pepper supply are Tellicherry, on the west coast of Hindostan, which is graded high, and Penang and Singapore for the East, Sumatra, Java, &c. The importations are principally through London, and not direct. The supply of ground pepper from England will usually be found more pure than our own brands and at the same time is naturally more expensive.

CAYENNE OR RED PEPPER.

The condiment should consist of the ground pods of any of several species of capsicum, known as chillis, or peppers. It is said to have been adulterated with many substances—brick dust, red lead, and coloring matters—but in Washington only rice has been detected, but that quite frequently. Inferior material is no doubt often ground, but the small value of the foods and the small quantity consumed do not tend to increase adulteration.

GINGER.

Ginger is the root, or, technically, rhizome, of a plant somewhat similar to our iris and flag. It is grown in various parts of the world and prepared with great care and great carelessness, being at times scraped and bleached, at others simply cut in any condition, and dried, so that there is a large number of varieties and qualities to be found in the market. They all, however, retain sufficiently the marked peculiarities of the starchy fibrous root to make the detection of adulterants easy. The common ones are the addition of wheat flour or some starch as a diluent, or the coloring with turmeric, to suit a popular fancy, for ginger-bread. Mustard hulls and Cayenne are also found in some States, but have not been detected here. They are added to give pungency and make up for the addition of flour. Their detection is easy. The sources of our supply are Jamaica and the West Indies, Cochin China, Africa, and India. That from Jamaica is the best and most carefully prepared.

CLOVES.

The flower buds of the clove tree, carefully picked and dried, constitute the spice known by that name. Their valuable properties are due to the volatile oil which they contain, the best having as much as 20.0 per cent.

The removal of this oil is so very easy, that it is the commonest method of deception to do so before grinding the spice and to then dispose of it as pure. We have ready means of determining the loss chemically, but the microscope gives no indication. The addition of the cheaper clove stems is also practiced, as they cost but 6 cents, when the buds cost 27. The microscope reveals their presence by certain cells which they contain which are absent in the buds. Pimento is sometimes substituted in part or entirely, as it has a clove-like flavor, but only 4 or 5 per cent. of volatile oil. It is worth less than one-fifth the price of cloves. Its chemical composition and its structure—that of a berry—reveals its presence. The addition of the coarser adulterants—cocoanut shells, flour, peas, and the like—have not been observed, but no doubt frequently occur, as has been found in Canada.

The sources of our supply are the East Indies (Amboyna), African (Zanzibar), and American, ranking in value in the order named. Cloves should, if possible, be always purchased whole, as they deteriorate less readily in that form.

CINNAMON AND CASSIA.

These spices are the barks of several spices of the genus *Cinnamomum*, the true cinnamon being a native of Ceylon, where it is largely

cultivated, and the cassias being derived from several spices growing in China, India, and the East Indies. Cinnamon as it reaches the market is very thin, the outer and inner coats of the bark having been removed. Cassia, on the other hand, is thick, as it consists of the entire bark, and can be distinguished by its retaining its natural outer surface. Cinnamon is by far more valuable than the cassia, as there is a smaller supply, and intrinsically, since it contains a much greater proportion of volatile oil and that of higher and more delicate aroma. In consequence cassia is largely substituted for cinnamon, and in fact not a particle of ground cinnamon can be found in the market. It can be found in the whole condition in good quality only in drug stores. Cassia exists in many forms and qualities, and sells at wholesale at from 7 to 40 cents a pound. That known as Saigon is the best, and that exported from Batavia the poorest. Cassia buds also hold a small place in the market.

The detection of the substitution of cassia for cinnamon, since the barks are of trees of the same species, is more difficult than is usually the case, and may prove troublesome to a novice. The presence of more woody fiber in the latter and the aid of chemical analysis serves, however, as reliable distinctions. In the samples which have come into our hands not a particle of material labeled "ground cinnamon" proved to be anything but cassia. The spice-millers appeared, however, to be satisfied to stop at this point, and no addition of cheap stuff to the cassia was detected. Should it be added there would be no difficulty in noting it, as has been done in Canada, where peas, starch, ground shells, and crackers have been found in powder labeled both cassia and cinnamon.

The barks can in most cases, and especially the cinnamon, be used nearly as well in the whole condition, and should at least be so purchased and then ground. A slight acquaintance with the appearance of the different qualities will teach one the proper selection to make.

NUTMEG AND MACE.

These spices are different portions of the fruit of a tree, known as the nutmeg tree, *Myristica fragrans*, the nutmeg being the kernel and the mace one of the outer coats or arillus. The tree grows principally in the Banda Islands, and the spices reach us through London. They can always be obtained in their original condition, and should be so purchased. When ground they are mixed with diluents of various descriptions, principally cereals or their refuse, which are easily detected. Owing to the infrequency of the sale of the powdered nutmeg and mace their adulteration has attracted but little attention.

CHARACTER OF THE SPICES IN THE DISTRICT OF COLUMBIA.

The spices found in Washington are from various markets. The first-class grocers carry the best English and some good American brands. Adulteration is infrequent, except among the mustards, peppers, and cinnamon, the former having lost its oil and added flour, and the latter having cassia substituted for it. Among the cheaper dealers adulterated spices are nearly universal, the supply being obtained largely from Baltimore, and to a small extent ground in Washington.

Of a series of samples collected impartially from all classes of shops the ratio of adulterated to non-adulterated was as follows:

Variety of spice.	Pure.	Adulterated.	Substituted.	Inferior.
Cassia	3			1
Cinnamon		1	10	3
Cloves	4	4		
Ginger	4	4		
Mace	3	1		
Mustard		*10		
Nutmeg	3			
Pepper:				
Black	1	9		
White	3	1		
Red	1	4		
Pimento	7	2		

* Oil expressed in one case and turmeric added, and oil expressed in all American brands.

Details of the peculiarities found in the above samples, with the methods employed in investigating them, will be found in the special bulletin of this division on food adulterations, together with chemical analyses of these and other samples, which cannot well be presented here, where it is intended merely to call the public attention by a few examples to the extent of adulteration of spices at the present day.

EXPERIMENTS IN THE MANUFACTURE OF SUGAR FROM SORGHUM.

The results of the experiments made at Ottawa last year gave encouragement to the friends of the sorghum sugar industry, and led to the undertaking of a new series of experiments at Fort Scott.

The diffusion battery consisted of fourteen cells, arranged in single line, with calorisators and apparatus for use of compressed air in discharging the water from each cell before dropping the exhausted chips. The working of the battery was entirely satisfactory.

Each cell had a capacity of 75 cubic feet, and would hold 1,900 pounds of sorghum chips, moderately packed. Each cell was constructed from the drawings obtained from the Fives-Lille Company, and the detailed description may be found in Bulletin No. 8.

The cutters used were those employed at Ottawa last year. With very sharp knives, and with cane fresh and green, they did reasonably good work, but after a frost had killed the leaves of the cane it was found almost impossible to make the cutters work. It often required half an hour to fill a single cell. When it is remembered that the rest of the apparatus could easily have worked a ton of chips each eight minutes, the disastrous effects of this delay can be appreciated.

From this cause great trouble was experienced in working the battery. When all the cells were in use each one was often under pressure three or four hours. The cane was unusually acid, and from this there followed a large inversion of sucrose in the battery. If, to avoid this, the temperature of diffusion was lowered, fermentation would set in. There was nothing left for us to do but to work a smaller number of cells. Often only six or seven cells were under pressure, and consequently the degree of extraction was far less perfect than it would have been otherwise.

The style of cutter used furnished a chip well suited to diffusion, but I am convinced that these cutters are more costly and require more power for operation than is necessary.

With a view of correcting these defects I purchased a beet-root cutter formerly used by the Portland Beet Sugar Company, and had it rebuilt by the Colwell Iron Company of New York, for an experimental cane-cutter.

This apparatus had a horizontal disk, and was so modified as to take a multiple feed, the cane being delivered to it through six hoppers inclined 40 degrees to the vertical. With perfectly clean canes this cutter gave promise of success, but with the sorghum cane as it came from the field it proved a total failure.

This leads me to believe that the cutters used at Java and other places so successfully with sugar-cane would not serve the purpose of slicing sorghum for the battery. Any question of cleaning the canes before delivering them to the cutter must be negatived on the score of economy.

For the further study of the problem I tried the system of cane slicing invented by Mr. H. A. Hughes, of Rio Grande, N. J.

The principle of this system consists in first cutting the canes into lengths of 3 or 4 inches by means of an ensilage-cutter, and after passing them through a cleaning apparatus deliver them to a shaving-machine, constructed on the principle of a board-planer.

This latter part of the apparatus was kindly loaned to the Department by Mr. Hughes.

The canes were first cut by a Belle City ensilage-cutter into pieces about 2.25 inches in length. These pieces were run though a fanning-mill and nearly all the blades and sheaths were thus removed. The clean pieces of cane were next delivered to a slicer built on the principle of an ordinary board-planer. The cylinder was 6 inches in diameter and 30 inches in length, and carried two knives projecting one-eighth to one-sixteenth inch beyond the surface. This was driven at a high rate of speed, over 3,000 revolutions per minute. The canes were shredded rather than sliced by this procees, so that the extraction of the sugar was rather a maceration than a diffusion.

Even with this small machine it was found possible to prepare nearly as much cane for the battery as with the three ponderous cutters described. It was found, however, that the ensilage-cutter was not strong enough to do the work, and hence this most promising system of cane-cutting, practiced successfully at Rio Grande, was discontinued. The experiment, however, led me to believe that the principle was the right one; especially is this so because it permits of the easy cleaning of the canes by first cutting them into small pieces. This seems to be the only practical way of accomplishing what is of prime necessity to diffusion, viz, the removal of all deleterious substances from the chips.

Having demonstrated the practicability of cleaning the cane in the manner already described, my attention was next directed to the consideration of the best method of cutting the short pieces of cane into chips suitable for diffusion. For this purpose I had constructed by the Fort Scott Foundry a centrifugal slicer. The theory of this apparatus was that the knives, being carried in a revolving frustum of a cone, and the short pieces of cane being fed from the inside of this cone, the chips, as soon as cut, would fly off by centrifugal force. A trial of this apparatus showed that the fiber of the cane would clog the knives and thus stop the work. The close of the season prevented any modification of the apparatus. I think the principle of the apparatus is promising enough to warrant further trial.

As a result of the experiments with cutters the following conclusions can be drawn:

(1) Whatever the form of the cutting-machine employed may be, it is necessary that the cane be cleaned. This cleaning should not consist of the removal of the blades alone, but also the sheaths.

(2) The slicing of the canes obliquely by means of a vertical cutting-machine with a forced feed is not an economical method of procedure.

(3) The use of a cutting-machine with a horizontal disk and multiple feed is impracticable for sorghum canes unless they are perfectly clean.

(4) The preliminary cutting of the canes into short lengths promises the easiest solution of the problem of cleaning the cane.

(5) The subsequent slicing of these sections by some form of apparatus is a mechanical problem which can be solved.

THE APPARATUS FOR DELIVERING THE CHIPS TO THE BATTERY AND REMOVING THEM THEREFROM.

The working of the chip elevators and the apparatus for removing the exhausted chips was exceedingly unsatisfactory.

The chips falling into the pit below the cutters were carried by a screw conveyer to a bucket elevator. Thence they were dropped onto a belt conveyer, which delivered them to the apparatus for blowing out the leaves, &c. The screw, the elevator, and the belt frequently became choked, and occasioned a great deal of trouble and delay.

The apparatus for removing the exhausted chips gave still greater trouble.

In discharging a cell the whole contents, weighing a ton, were thrown at once on the conveyer. This load was too great, and many days' delay were experienced in making the alterations necessary even to moderate efficiency.

The elevator for taking the exhausted chips from this conveyer was a very complicated and inefficient piece of apparatus, and many tedious changes had to be made before it would do the necessary work. Finally its use was abandoned altogether. The lessons taught by these unfortunate delays show that the proper method for removing the exhausted chips from the battery is by means of a tramway and dump-cart, as practiced at Almeria, and described in Bulletin No. 8. A great deal of apparatus and power will be saved by this method of disposing of the chips. The conveyer for filling the cells worked in marked contrast with the rest of the chip-handling machinery, and gave perfect satisfaction. This conveyer extended the entire length of the battery, and was placed directly above it. Over each cell was a door in the floor of the conveyer. When a cell was to be filled the door above it was opened and the chips fell through onto a funnel, which directed them into the cell. The bottom of the conveyer at Fort Scott was too near the top of the cells. It should be not less than 6 feet above the top of the cells, so as to allow ample room for tamping the chips as they fall into the cell, thereby greatly increasing the capacity of the battery. I do not think a better contrivance could be devised for filling the cells of a line battery. I am still of the opinion, however, that the charging of a circular battery, as described in Bulletin No. 8, would be a more simple method. The disposition of the battery, however, is not a matter of vital importance.

I am further of the opinion that it will not be difficult for an ingeni-

ous mechanical engineer familiar with elevating apparatus to build the machinery which will elevate the cuttings to the battery without any difficulty. By the employment of the centrifugal cutter already described, which can be placed directly over the battery, the elevators will only have to carry the short pieces of cane—a very easy task.

MACHINERY FOR HANDLING THE CANE.

The apparatus for taking the cane from the carts and delivering it to the cutters was designed by Mr. W. L. Parkinson. The carts for bringing the cane from the fields are provided with a rack of peculiar construction. On this rack are placed ropes in such a manner that when the cart arrives at the unloading station the ropes can be brought together, inclosing the whole load of cane. By means of a power drum the entire load is drawn from the cart onto a weighing-truck, running on a tramway.

As soon as the weighing is completed the truck is moved along the way until it comes opposite the cane-carrier. It is drawn from the truck by means of a power drum, and is dragged down an inclined plane in large armfuls to the carrier. The carrier runs at right angles to the length of the cane and to the elevators which deliver the canes to the cutters. As the cane is carried along this feed-table the heads are cut off by a circular saw running at a high rate of speed. The heads which escape the saw are afterwards cut off by hand. The canes then pass to a point midway over the three elevators leading to the cutters. Thence, by means of an ingenious contrivance, it can be dropped into either carrier at will. The apparatus worked well, but aside from the removal of the tops I doubt whether so complicated a piece of machinery is necessary.

CARBONATATION APPARATUS.

This apparatus consists of a lime-kiln, washer for the gas, carbonic-acid pump, and carbonatation tanks.

LIME-KILN.

The lime-kiln was built by Mr. G. L. Spencer, with castings and plans from the Hallesche Maschinenfabrik. The pump was built by the same firm, but was purchased, as well as the castings just mentioned, from the Portland Beet Sugar Company. After the workmen learned how to conduct the operations at the kiln we had no trouble with its manipulation. It furnished an abundant supply of gas, and an amount of lime in large excess of the quantity required.

The limestone at first furnished contained a large quantity of cement, and was unfit for use. In all, several days' delay was caused by this imperfection.

After reasonably good limestone was obtained all worked well. The analyses of the limestones employed will be found among the analytical data. The drawings and detailed description of the lime-kiln are found in Bulletin No. 8.

THE PUMP.

The pump was delivered to us in that state of imperfection which three months of very hard usage and six years of disuse produce. Nevertheless, after a proper adjustment it worked with perfect satisfaction. In all not more than half a day's delay was caused by the adjustment of this apparatus.

THE CARBONATATION TANKS.

These tanks were built by the Pusey & Jones Company, according to the drawings and specifications in Bulletin No. 8, and gave perfect satisfaction. I can suggest no improvement in them, unless it be the insertion of revolving paddles, to keep down the foam.

THE FILTER-PRESSES.

These, four in number, and of thirty chambers each, were constructed by the Pusey & Jones Company, on the general plan of the Kroog filter-press, but with certain modifications suggested and patented by Mr. Swenson. Their work gave perfect satisfaction. The only fault discovered in them was the weakness of the plates, a great number of them breaking under the ordinary pressure.

THE SULPHUR APPARATUS.

This apparatus consists of an air-compressor, two sulphur furnaces, three sulphuring-tanks, and three Kroog's twin filter-presses. The whole apparatus was built by the Sangerhäuser Maschinenfabrik, and its work gave entire satisfaction. The apparatus is described in detail in Bulletin No. 8.

The whole of the machinery, with the unimportant changes noted, was constructed according to the drawings and specifications printed in Bulletin No. 8. Their reproduction is not considered necessary here.

ANALYTICAL DATA.

The analyses of canes, chips, waste waters, purified juices, &c., were made at the factory chiefly by Dr. C. A. Crampton, assisted by Mr. N. J. Fake. The limestones, masse cuites, press cakes, &c., were examined in the laboratory at Washington.

The analyses of the gases from the lime-kiln were made by Mr. G. L. Spencer.

The full details of these analyses are given in Bulletin No. 14.

Mill juices before October 1.

Number.	Extraction.	Specific gravity.	Solids.	Sucrose.	Glucose.	Date.	Index to mill juices.
	P. ct.		*P. ct.*	*P. ct*	*P. ct.*		
1......	55.26	1.0773	18.7	13.25	......	Aug. 30	Early amber cane from west field.
2......	53.33	1.0669	16.3	11.46	1.88	Aug. 31	Early amber cane from east field.
3......	57.14	1.0529	13.1	7.20	3.46	Aug. 31	Link's hybrid.
4......	58.83	1.0574	14.1	7.50	4.35	Aug. 31	Early orange.
5......	......	1.0710	17.2	14.73	....	Sept. 3	Early amber cane, juice extracted by hand.
28......	60.60	1.0770	18.6	9.47	4.95	Sept. 15	Early amber cane from east field, cut two days.
31......	60.00	1.0788	19.0	7.04	7.80	Sept. 16	Early amber cane, cut three days.
37......	51.60	1.0794	19.2	4.92	8.42	Sept. 17	Orange cane from wagons.
44......	......	1.0688	16.7	10.83	2.49	Sept 18	Cane from carrier.
53......	45.16	1.0832	20.0	13.54	2.97	Sept. 19	Do.
61......	47.15	1.0734	17.8	11.48	3.58	Sept. 20	Amber cane from carrier.
70......	68.68	1.0770	18.6	12.11	2.44	Sept 21	Amber cane from carrier, cut yesterday.
71......	56.10	1.0750	18.2	11.82	2.73	Sept. 21	Orange cane from carrier.
84......	55.27	1.0818	19.5	11.02	4.20	Sept. 22	Amber cane from carrier, cut two days.
85......	58.62	1.0888	21.2	14.50	2.77	Sept. 22	Amber cane from carrier, cut one day.
87......	53.12	1.0848	20.3	3.60	11.36	Sept. 23	Amber cane from carrier, cut three days.
88......	61.77	1.0718	17.4	9.49	5.33	Sept. 23	Cane from carrier.
89......	58.44	1.0638	15.6	9.74	2.16	Sept. 23	Link's hybrid from field.
95......	46.43	1.0776	18.7	13.53	2.41	Sept. 24	Cane from carrier.
97......	56.56	1.0675	16.4	11.50	2.80	Sept. 24	Cane like preceding, except badly lodged.
102......	59.37	1.0578	14.2	8.20	2.86	Sept. 25	Cane from carrier (from lodged lot).
103......	59.18	1.0678	16.5	10.17	3.47	Sept. 25	Orange cane, cut to-day.
106½......	53.00	1.0726	17.6	12.40	1.90	Sept. 28	Cane from carrier.
112......	51.51	1.0684	16.6	10.41	4.08	Sept. 29	Do.
119......	56.10	1.0764	17.8	12.39	3.76	Sept. 30	Do.
Av'age.	55.79	1.0723	17.56	10.49	4.01		
Coefficient purity......			59.73				

Mill juices after September 30.

Number.	Extraction.	Specific gravity.	Solids.	Sucrose.	Glucose.	Date.	Index to mill juices.
	P. ct.		*P. ct.*	*P. ct.*	*P. ct.*		
126.....	61.76	1.0634	15.5	8.37	4.95	Oct. 1	Cane from carrier, stripped.
131.....	....	1.0842	20.2	14.50	1.77	Oct. 2	Cane from carrier.
138.....	54.54	1.0866	20.7	14.37	2.16	Oct. 3	Cane brought in cars from Hammond.
147.....	51.72	1.0680	16.6	10.50	2.60	Oct. 4	Amber cane from carrier.
150.....	51.35	1.0740	17.9	12.39	1.92	Oct. 4	Orange cane from carrier.
159.....	51.35	1.0710	17.2	10.65	3.27	Oct. 5	Cane from carrier.
169.....	56.00	1.0818	19.7	13.20	2.37	Oct. 5	Cane, amber, on car from Hammond.
170.....	57.70	1.0778	18.8	9.95	4.88	Oct. 5	Same, orange.
176.....	52.94	1.0801	19.3	2.11	......	Oct. 7	Amber cane from Hammond.
177.....	53.85	1.0748	18.1	6.67	......	Oct. 7	Same, orange.
180.....	55.55	1.0698	17.0	10.69	3.11	Oct. 7	Cane from car, same as two preceding, but better averaged samples taken from center of car, while the first samples were taken from the outside, amber.
181.....	53.12	1.0828	19.9	12.46	3.03	Oct. 7	Same, orange.
199.....	60.10	1.0678	16.5	9.10	4.36	Oct. 8	Orange cane from carrier (juice very red).
207.....	59.63	1.0640	15.6	9.07	3.84	Oct. 8	Cane from carrier, p. m.
213.....	58.08	1.0758	18.3	4.55	9.62	Oct. 9	Cane from carrier, a. m. (old cane).
222.....	58.82	1.0596	14.6	8.57	2.20	Oct. 9	Link's hybrid from field.
223.....	61.54	1.0556	13.7	7.72	3.38	Oct. 9	Orange from field.
224.....	60.00	1.0506	12.5	7.22	4.09	Oct. 9	Amber from field.
231.....	59.37	1.0766	18.5	7.02	7.74	Oct. 10	Cane from carrier, cut several days.
232.....	62.07	1.0764	18.5	8.66	3.04	Oct. 10	First fresh wagon-load lot in to-day.
241.....	57.90	1.0676	16.5	10.29	2.13	Oct. 11	Link's hybrid cane from Professor Swenson's, still green and not hurt by frost.
242.....	....	1.0618	15.1	8.60	3.25	Oct. 11	Cane from carrier, freshly cut, a. m.
249.....	61.90	1.0632	15.5	8.86	2.98	Oct. 11	Cane from carrier, p. m.
258.....	62.16	1.0588	14.4	6.65	4.72	Oct. 12	Cane from carrier.
259.....	57.14	1.0718	17.4	8.54	5.04	Oct. 12	Cane on car from Hammond, orange.
260.....	58.83	1.0736	17.8	10.51	3.27	Oct. 12	Cane on car from Hammond, amber.
267.....	59.09	1.0592	14.5	8.83	3.10	Oct. 12	Cane, amber, lot from Hammond by Dr. Wiley and Professor Swenson.
268.....	61.54	1.0832	20.0	14.11	1.95	Oct. 12	Same, orange.
269.....	63.41	1.0672	16.4	9.53	4.56	Oct. 12	Same, orange, No. 2.
276.....	53.63	1.0956	21.5	5.71	11.41	Oct. 13	Cane for experimental run, orange, taken from same cars as yesterday's samples.
277.....	57.25	1.0846	20.3	12.05	4.19	Oct. 13	Same, amber.
279.....	59.46	1.0656	16.0	7.68	5.17	Oct. 13	Sample from other two cars from Hammond, orange.
280.....	62.07	1.0646	15.8	7.27	5.52	Oct. 13	Same, amber.
281.....	60.71	1.0654	16.0	10.09	2.23	Oct. 13	Orange cane from Professor Swenson's.
284.....	52.94	1.0618	15.1	4.15	7.84	Oct. 13	First mill juice from experimental run, taking sample every hour, orange.
285.....	62.50	1.0608	14.9	4.64	7.25	Oct. 13	Same, amber, taken at same time as above.
287.....	....	1.0621	15.2	5.83	6.07	Oct. 13	Second sample, orange.
288.....	50.00	1.0626	15.3	9.51	2.44	Oct. 13	Second sample, Link's hybrid, from Swenson's.
290.....	60.00	1.0678	16.5	9.77	3.75	Oct. 13	Third sample, orange, from Hammond.
294.....	56.52	1.0684	16.6	8.51	4.12	Oct. 14	Cane from carrier, amber.
295.....	62.86	1.0629	15.4	7.88	4.38	Oct. 14	Cane from carrier, orange.
310.....	....	1.0580	14.3	7.45	4.50	Oct. 15	"Denton" cane, analyzed for Mr. Parkinson.
311.....	....	1.0400	10.0	3.66	3.31	Oct. 15	Green cane from wagon.
442.....	61.58	1.0560	13.8	5.87	4.98	Oct. 23	Cane from field across railroad, amber, still green.
458.....	60.00	1.0550	13.6	7.60	1.97	Oct. 25	Cane from field south side railroad track, amber.
Av'age.	58.01	1.0680	16.60	8.70	4.15		
Coefficient purity......			52.41				

ANALYSES OF JUICE OF CHIPS FROM CUTTERS.

These chips were taken from the cells of the battery as they were filling. A handful was taken from each cell until 10 had been sampled.

The determinations were made by passing these chips through the mill and then subjecting the juice to examination in the usual way.

Mill juices from chips taken from circuit of cells.

Number.	Date.	Specific gravity.	Solids.	Sucrose.	Glucose.
			Per cent.	*Per cent.*	*Per cent.*
308	Oct. 15	1.0624	15.3	9.02	2.61
312	Oct. 15	1.0610	14.9	7.84	3.42
326	Oct 16	1.0670	16.3	9.29	3.35
340	Oct. 17	1.0648	15.8	8.17	3.68
355	Oct. 18	1.0584	14.3	7.21	3.31
372	Oct. 19	1.0596	14.6	7.69	3.31
390	Oct. 20	1.0648	15.8	8.82	3.48
412	Oct. 21	1.0590	14.5	7.48	3.31
429	Oct. 22	1.0618	15.1	6.17	4.18
445	Oct 23	1.0510	12.6	5.77	4.44
460	Oct. 26	1 0580	14.2	5.42	4.85
473	Oct. 27	1.0578	14.2	4.50	4.95
Means		1.0605	14.8	7.28	3.74
Means in cane			13 17	6.48	3.31

Purity coefficient of juice, 49.
Glucose per 100 sucrose in juice, 51.07.

Diffusion juices to October 1.

Number.	Date.	Solids.	Sucrose.	Glucose.
		Per cent.	*Per cent.*	*Per cent.*
13	Sept. 9	6.8	3.29	1.39
16	Sept. 11	8.5	3.94	1.99
23	Sept. 13	9.3	6.50	1.66
25	Sept. 14	11.7	7.47	1.53
27	Sept. 14	11.2	6.17	1.42
29	Sept. 15	12.6	6.36	2.84
32	Sept. 16	10.8	5.71	1.82
38	Sept. 17	10.4	5.62	1.66
46	Sept. 18	11.9	6.59	3.18
51	Sept. 18	11.7	6.94	1.82
57	Sept. 19	11.8	5.66	2.85
64	Sept. 20	10.8	4.37	3.36
69	Sept. 20	12.3	5 59	3.46
77	Sept 21	11.8	5.76	2.89
91	Sept 23	11.8	6.78	2.19
94	Sept. 24	9.2	4.81	1.84
98	Sept. 24	10.7	4.53	2.23
101	Sept. 25	9.6	6.06	1.52
104	Sept. 25	8.9	4.13	1.28
108	Sept. 28	9.7	5.68	1.67
114	Sept. 29	12.6	6.76	2.92
118	Sept. 29	12.0	6.37	2.65
122	Sept. 30	14.8	7.22	4.16
Average		11.77	5.75	2.32

Purity coefficient of juice, 48.93.

Diffusion juices October 1 to close.

Number.	Date.	Solids.	Sucrose.	Glucose.
		Per cent.	*Per cent.*	*Per cent.*
128	Oct. 1	14.8	8.60	3.25
132	Oct. 2	13.7	7.01	3.33
133	Oct. 2	13.9	7.68	3.10
134	Oct. 2	13.2	7.18	2.75
139	Oct. 3	12.9	5.89	3.96
140	Oct. 3	12.7	6.51	3.65
141	Oct. 3	12.9	6.47	3.52
149	Oct. 4	9.8	4.80	2.38
152	Oct. 4	9.6	4.71	2.47
155	Oct. 4	11.5	5.42	3.28
160	Oct. 5	12.3	6.21	3.34
163	Oct. 5	13.0	6.44	3.58
166	Oct. 5	12.2	5.78	3.40
171	Oct. 5	12.2	6.03	3.23
179	Oct. 7	13.3	6.13	4.41
182	Oct. 7	12.7	5.46	4.23
183	Oct. 7	12.2	5.19	4.23
184	Oct. 7	12.2	4.50	4.41
201	Oct. 8	12.5	5.40	4.12
205	Oct. 8	11.8	5.29	3.98
216	Oct. 9	12.2	4.04	4.65
217	Oct. 9	11.3	4.08	4.07
229	Oct. 10	10.8	4.06	3.45
237	Oct. 10	11.2	4.86	3.30
244	Oct. 11	10.3	4.10	3.43
247	Oct. 11	10.3	4.32	3.15
254	Oct. 11	10.9	4.53	3.09
261	Oct. 12	13.1	5.76	3.96
262	Oct. 12	12.2	4.82	4.06
271	Oct. 12	11.9	5.44	3.41
296	Oct. 14	12.7	5.30	2.14
300	Oct. 14	11.6	4.92	3.54
313	Oct. 15	9.1	3.24	2.32
327	Oct. 16	11.6	5.14	2.98
328	Oct. 16	11.2	4.96	2.94
339	Oct. 17	11.7	5.51	3.08
356	Oct. 18	10.8	4.38	2.90
357	Oct. 18	9.8	3.64	2.96
371	Oct. 19	9.9	4.08	2.53
373	Oct. 19	10.4	4.38	2.94
389	Oct. 20	10.9	3.72	3.91
395	Oct. 20	7.2	2.33	2.08
404	Oct. 20	9.5	3.58	2.71
410	Oct. 21	11.2	3.97	3.98
417	Oct. 21	11.8	3.77	4.44
428	Oct. 22	10.6	4.41	3.31
430	Oct. 22	10.1	3.95	3.37
435	Oct. 22	10.3	3.91	3.43
441	Oct. 22	10.3	3.82	3.76
444	Oct. 23	10.1	3.67	3.77
453	Oct. 23	10.1	3.41	3.63
468	Oct. 26	8.8	2.93	2.97
478	Oct. 27	7.8	2.94	2.55
Average		11.34	4.90	3.39

After September 30 the determinations are as follows:

	Per cent.
Glucose in mill juices	4.15
Not sugars in mill juices	3.75

Ratio 1 glucose to .90 not sugars.

Glucose in chips	4.15
Not sugars in chips (calculated)	3.74
Sucrose	7.01
Total solids	14.90
Purity of chips before October 1	60.5
Purity of chips after September 30	47.1

JUICE FROM CHIPS PASSED THROUGH EXPERIMENTAL MILL.

From the analyses of the juices it is seen that the chips entering the battery from October 15 to the close of the season contained—

	Per cent.
Sucrose	6.48
Glucose	3.31
Glucose per hundred of sucrose	51.07

Leaving out of the computation the analyses of the chips in closed bottles, the following average character of the cane for the entire season is obtained:

	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
Before October 1	15.63	9.34	3.57
After September 30	14.77	7.74	3.79
After October 14	13.17	6.48	3.31
Means	14.56	7.85	3.52

Mean purity, 53.9; mean glucose per 100 sucrose, 43.84.
Available sugar, calculated by taking difference between sucrose and all other solids, viz, 1.15 per cent.=23 pounds per ton.

It will be interesting to compare these numbers with those obtained at Magnolia Station, Louisiana, in 1885, and recorded in Bulletin No. 11, pp. 11, 12.

	Per cent.
Total solids in cane	14.22
Total sucrose in cane	10.90
Total glucose in cane	.92
Mean purity	76.6
Mean glucose per 100 sucrose	8.44

Available sugar calculated as before, viz, 7.58 per cent.=151.6 pounds per ton.

It thus clearly appears from a careful study of the analytical data that the sorghum canes entering the battery at Fort Scott were totally unfit for sugar-making.

No known process, save an act of creation, could have made sugar successfully out of such material.

If nothing better than this can be obtained, then it is time to declare the belief in an indigenous sorghum-sugar industry a delusion. This subject will be mentioned again in the summary.

A general review of the data connected with this interesting problem shows that with fresh chips of fine quality the natural acidity is capable of producing no appreciable inversion during treatment in an extraction flask or while under pressure in the battery. With the deterioration of the cane, however, and consequent increasing acidity, this inversion becomes very great. In other words, the natural acids of the cane, such as malic and aconitic, are incapable of producing any appreciable inversion; but the accidental acid (acetic) which comes from deterioration may cause an inversion of the sucrose in a most marked degree. The most practical method of avoiding this danger appears to me to be a mechanical contrivance which will sprinkle evenly over the entering chips 2 or 3 pounds of fine slaked lime or double that quantity of fine calcium carbonate to each cell of chips.

As has already been noted, every other attempt to neutralize the dangerous acids of the cane in a practical way has failed.

DIFFUSION JUICES.

The ratio of glucose to sucrose (per 100) in the diffusion juices was as follows:

	Per cent.
Before October 1	39.95
After September 30	68.15

These results show that before frost the inversion of the sucrose in the battery was nil, but that after frost this inversion was very marked. The fact is also emphasized by another, viz, that before frost the full battery of 14 cells was used, but that afterwards 8, 10, and 12 cells only were employed. Thus before frost the chips in the battery were longer under pressure than afterwards, and I may add that the temperature was also higher. These facts corroborate the statement already made, that when once the process of inversion has commenced it goes easily and rapidly forward under the combined influence of time and an elevated temperature. Before such deterioration begins a temperature of even 100° C. can be maintained for an hour without notable injury.

A further fact which is illustrated by the analyses of the diffusion juices from uninjured canes is that the diminished purity is produced solely by the extraction of gum and chlorophyll, chiefly from the blades and sheaths, and that this injury can be avoided by a proper cleaning of the canes.

With clean canes and those in which the sucrose is still uninjured no alkaline substance will have to be used in the battery. When, however, deteriorated canes are used, some such application will be necessary to save the sucrose from further inversion. As has already been pointed out, finely powdered lime or calcium carbonate evenly distributed over the chips offers the simplest solution of the difficulty.

WASTE WATERS AND EXHAUSTED CHIPS.

The amount of waste water was very small, compressed air having been uniformily used to drive the water from the cell next to be discharged.

In the estimation of the sugar the sucrose was first inverted and the whole sugar estimated as glucose. The mean percentage of both sugars in the waste waters after September 30 was .17 per cent. Since the mean glucose per 100 of sucrose for the season was nearly 44, the respective quantities of sucrose and glucose were as follows:

	Per cent.
Sucrose	.11
Glucose	.06

In the exhausted chips before October 1, by the same method of calculation, there was of—

	Per cent.
Sucrose	.16
Glucose	.08

After September 30 the numbers are as follows:

	Per cent.
Sucrose	.35
Glucose	.17

This increase in the sugar left in the chips was was due to cutting out a large portion of the battery, especially during the first week in October. At this time often only six cells were under pressure, but

the result is seen in the large quantities of total sugar left in the chips, amounting in one instance to 1.52 per cent.

After the 6th of October nine or ten cells were kept under pressure, and the content of sugar left in the chips was correspondingly diminished.

Sorghum, however, lends itself to diffusion more readily than any other sugar-producing plant, and a battery of ten cells properly managed would give good results as far as extraction is concerned.

PRESS CAKES.

The mean weight of the press cakes was 24.3 pounds. The mean content of moisture was 46.45 per cent.

Since considerable time elapsed from the time of sending the cakes from Fort Scott until they were analyzed at Washington a considerable inversion of the sucrose took place.

The mean total sugar in the twelve press cakes examined was 4.42 per cent.

Dividing this, as before, between the two sugars, we find, of—

	Per cent.
Sucrose	2.97
Glucose	1.45

When extra care was taken in washing the cakes, as in the case of the Louisiana experiments, to be later described, only a trace of sugar was left in them.

A glance at the composition of the cake will show its value as a fertilizer.

The quantity of lime used was nearly 1½ per cent. of the weight of the cane entering the battery.

RESULTS OF WORK.

The average weight of chips in the cells was 1,900 pounds.

From the beginning of the first attempts to run the machinery (September 13) until it was found possible to save the product (September 29) 499 diffusions were made, amounting to 948,100 pounds. After beginning to save the product (September 29) until suspension of work (October 26) 1,945 diffusions were made, amounting to 3,695,500 pounds. The total weight of cane, seed, and blades received from the field after September 19 was 3,120 tons.

The weight of chips diffused was 2,322 tons. The weight of seed, tops, blades, and cleanings (by difference) was 798 tons.

Following is the number of cells of chips used each day after September 19. Before that date no separate daily account was kept:

Date.	Number of cells cut.	Date.	Number of cells cut.	Date.	Number of cells cut.
Sept. 20	30	Oct. 2	69	Oct. 14	80
Sept. 21	59	Oct. 3	56	Oct. 15	75
Sept. 22	44	Oct. 4	79	Oct. 16	100
Sept. 23	67	Oct. 5	55	Oct. 17	85
Sept. 24	89	Oct. 6	53	Oct. 18	55
Sept. 25	63	Oct. 7	66	Oct. 19	53
Sept. 26	66	Oct. 8	59	Oct. 20	91
Sept. 27	41	Oct. 9	70	Oct. 21	102
Sept. 28	33	Oct. 10	79	Oct. 22	106
Sept. 29	75	Oct. 11	92	Oct. 23	99
Sept. 30	66	Oct. 12	85	Oct. 26	42
Oct. 1	67	Oct. 13	66		
Total					2,419

About one-third of the cane received was partly stripped of its blades. It appears from the above figures that the seed tops, blades, and sheaths of the cane will amount to nearly 30 per cent. of the entire weight. It must also be remembered that much of the blades, sheaths, &c., was not removed by the very imperfect cleaning apparatus employed, and this weight is included in that of the "clean chips."

STATEMENT SHOWING RATIO OF SEED HEADS TO WEIGHT OF CANE, RATIO OF CLEANINGS FROM BLOWER, AND QUANTITY OF CLEAN CANE CHIPS PER CELL.

Weight of cane taken	pounds	118,480
Weight of seed tops	do	21,875
Weight of cleanings	do	7,580
Weight of clean cane chips	do	89,025
Weight of each cell full of clean chips	do	1,894
Seed heads to total weight of cane	per cent	18.47
Cleanings total weight of cane	do	6.40
Clean chips on total weight of cane	do	75.13

The cane used in the above experiments was stripped in the field. The "cleanings" comprised the blades not removed and sheaths, &c., blown out by the fanning-machine. Much of these impurities was not removed. The sugar obtained was of a fair marketable kind and found a ready sale. The molasses was of a dark color and a poor quality.

The weight of *masse-cuite* was determined on a portion of the product by Mr. Swenson. He placed it at a mean of 12 per cent. of the weight of the chips entering the battery. The weight of melada obtained from the 2,322 tons was therefore 557,280 pounds, or 46,440 gallons.

At the present writing (November 15) all of the sugar has not been swung out, but the product will be about 50,000 pounds. This is indeed a discouraging yield, and quite in contrast with the phenomenal quantity obtained from sugar-cane from Louisiana, to be mentioned further along. If a proper crystallizing room had been provided by the company the yield of sugar would have been much larger. On November 2 the different parts of the crystallizing room were found to be of the following temperatures:

	Degrees F
Northeast corner	84
North center	84
Three feet above floor, under north steam drum	72
Northwest corner	75
In upper layer of sirup in wagon, under south steam drum	105.8
Bottom of same wagon	77
South center	79
Southwest corner, over office	79
Between steam drums	80.1
Temperature of air outside in shade	64.4

At such a low temperature a *masse-cuite* poor in sucrose and boiled to string proof cannot crystallize to advantage.

Before beginning the experiments with sugar-cane about to be described I obtained permission of the company to provide a special hot-room. With such material and with such unfavorable conditions of crystallization the yield of over 20 pounds of sugar per ton is a convincing proof of the efficiency of the process employed.

DISPOSITION OF THE EXHAUSTED CHIPS.

The problem of the disposition of the exhausted chips is one of great importance. By the failure of the machinery which was designed to remove the chips to a considerable distance from the building the chips had to be taken away by scrapers. When it is remembered that these chips have slightly increased in weight in passing through the battery the great expense of this proceeding is at once apparent.

The percentage of water in the discharged chips was found to be as follows:

Number.	Per cent.	Number.	Per cent.
1	84.89	7	89.68
2	86.73	8	88.87
3	87.54	9	88.94
4	86.41	10	88.86
5	88.62		
6	90.43	Mean	88.10

Since the mean of former experiments shows that sorghum contains about 11 per cent. fiber and matters insoluble in water, the composition of the waste chips, as indicated by the above determination, is:

	Per cent.
Fiber	11.00
Water	88.10
Other substances	.90
Total	100.00

After passing the waste chips through the mill they had the following percentage of water:

Number.	Per cent.
1	66.57
2	63.74
3	63.06
4	67.73
Mean	65.28

At 70 per cent. extraction the bagasse therefore contains 1 part of fiber to 2 of water. By a short preliminary drying this bagasse would readily burn. At any rate, it presses so readily, requiring so little power, that in my opinion it would be a matter of economy to pass it through a three-roll mill.

The percentage of extraction obtained with the spent chips in small experimental mill will be seen by the following numbers:

The first column represents the per cents. calculated from weighing the bagasse and the second from weighing the expressed water:

Number.	From bagasse.	From water.
	Per cent.	*Per cent.*
1	73.06	79.65
2	72.16	68.31
3	80.00	64.35
4	72.80	69.20
5	70.80	65.33
Mean	73.76	69.17

Since it is difficult to accurately collect and weigh the fine bagasse which the spent chips afford, the mean of the second column will be found to represent more accurately the real extraction. It is certain that with a good three-roll mill each 100 pounds of the spent chips can be reduced to 30 pounds, one-third of which is combustible material. Even if no attempt is made to use the bagasse as a fuel, the pressure is to be recommended on the score of economy. There appears to be no difficulty whatever in passing the chips through a three-roll mill, and their soft and pulpy state renders the pressure exceedingly easy.

Further reference to this point will be made in that part of the report devoted to sugar-cane.

MODIFICATION OF THE PROCESS OF CARBONATATION.

In order to avoid the discoloration of the sirup, which is the chief objection to carbonatation, the following modification of the process was adopted:

The juice used was obtained from sugar cane sent from Fort Scott to Washington, and the experiments were made after my return from Kansas.

To the cane juice was added 1 per cent. of its weight of freshly burned lime, and the carbonatation was continued until the juice was almost neutral. After raising to the boiling point to decompose sucro-carbonates the juice was filtered, and then enough phosphoric acid added to precipitate the lime remaining in solution.

Since a slight excess of the acid will redissolve the precipitate and form acid phosphate, sodium phosphate was substituted for the phosphoric acid.

Much of the red color of the carbonatated juice was discharged by this process. After the precipitation was complete the juice was again boiled and filtered. It was then bleached with sulphurous acid and evaporated to 40° B.

In every instance the sirup made in this way was very light in color, perfectly transparent, and of the finest flavor. So pure was it, indeed, that it was found unnecessary to use any acetate of lead or any other defecating material to prepare this sirup for polarization. The quantity of phosphate of soda required to precipitate the lime in 5 liters of juice (11 pounds) was 100 cubic centimeters of a 10 per cent. solution. Therefore 10 grams of the sodium phosphate are sufficient for 5,000 grams of juice. About 4 pounds of sodium phosphate or 3 pounds of phosphoric acid would be sufficient for working a ton of cane.

The whole cost of treating cane juices with phosphoric acid or sodium phosphate will not be over 15 cents per ton of cane. The phosphoric acid, however, is not lost. It will reappear in the press cakes, having lost only half its value. Hence the actual cost of using this method of removing the lime is not probably over half of the estimate given above.

I made every effort to get phosphoric acid at Fort Scott, but could not succeed in time.

I believe the modification of the process here suggested will make a noted improvement in the molasses over any other procedure now in use.

GENERAL CONCLUSIONS.

In a general review of the work, the most important point suggested is the absolute failure of the experiments to demonstrate the commercial practicability of manufacturing sorghum sugar. The

causes of this failure have been pointed out in the preceding pages, and it will only be necessary here to recapitulate them. They were:

(1) Defective machinery for cutting the canes and for elevating and cleaning the chips and for removing the exhausted chips.

(2) The deterioration of the cane, due to much of it becoming over-ripe, but chiefly to the fact that much time would generally elapse after the canes were cut before they reached the diffusion battery. The heavy frost which came the 1st of October also injured the cane somewhat, but not until ten days or two weeks after it occurred.

(3) The deteriorated cane caused a considerable inversion of the sucrose in the battery, an inversion which was increased by the delay in furnishing chips, thus causing the chips in the battery to remain exposed under pressure for a much longer time than was necessary. The mean time required for diffusing one cell was twenty-one minutes, three times as long as it should have been.

(4) The process of carbonatation, as employed, secured a maximum yield of sugar, but failed to make a molasses which was marketable. This trouble arose from the small quantity of lime remaining in the filtered juices, causing a blackening of the sirup on concentration, and the failure of the cleaning apparatus to properly prepare the chips for diffusion.

A modification of the process, which will prevent this trouble, has already been explained; but, although an earnest attempt was made to introduce this method, it was found impossible to accomplish it before the end of the season.

In the preceding report I have endeavored to lay before you all the facts noted in the recent experiments. If I have not interpreted them correctly, I have at least given the data for a correct interpretation.

I should, indeed, be glad to leave this industry in a more promising condition. All admit that the process of diffusion has been successfully worked out, and to this opinion I subscribe, with the reservation that a proper mechanical method for distributing over the chips a substance to prevent inversion of the sucrose has not yet been discovered.

Honest differences of opinion still exist in respect of the best method of treating the diffusion juices, but it has been shown at Rio Grande that the diffusion juice from clean cane can be worked without any purification whatever.

Whether this purification is to be accomplished by carbonatation, filtering with brown coal, or in some other way, can easily be decided without menacing the future of the sorghum industry.

The problem of successfully cutting and cleaning the canes does not appear to me to be incapable of solution. It should have been solved the first thing, without leaving it for the last.

Last of all, the chief thing to be accomplished is the production of a sorghum plant containing a reasonably constant percentage of crystallizable sugar.

I cannot emphasize this point better than by quoting from some of my previous reports. In Bulletin No. 3, pp. 107, 108, the following words are found:

IMPROVEMENT BY SEED SELECTION.

I am fully convinced that the Government should undertake the experiments which have in view the increase of the ratio of sucrose to the other substances in the juice. These experiments, to be valuable, must continue under proper scientific direction for a number of years. The cost will be so great that a private citizen will hardly be willing to undertake the expense.

The history of the improvement in the sugar beet should be sufficient to encourage all similar efforts with sorghum.

The original forage beet, from which the sugar beet has been developed, contained only 5 or 6 per cent. of sucrose. The sugar beet will now average 10 per cent. of sucrose. It seems to me that a few years of careful selection may secure a similar improvement in sorghum.

It would be a long step toward the solution of the problem to secure a sorghum that would average, field with field, 12 per cent. sucrose and only 2 per cent. of other sugars, and with such cane the great difficulty would be to make sirup and not sugar. Those varieties and individuals of each variety of cane which show the best analytical results should be carefully selected for seed, and this selection continued until accidental variations become hereditary qualities in harmony with the well-known principles of descent.

If these experiments in selection could be made in different parts of the country, and especially by the various agricultural stations and colleges, they would have additional value and force. In a country whose soil and climate are as diversified as in this results obtained in one locality are not always reliable for another.

If some unity of action could in this way be established among those engaged in agricultural research, much time and labor would be saved and more valuable results be obtained.

In Bulletin No. 5, pp. 185–187, are found the following conclusions:

A careful study of the foregoing data will not fail to convince every candid investigator that the manufacture of sugar from sorghum has not yet proved financially successful.

The men who have put their money in these enterprises seem likely to lose it, and intending investors will carefully consider the facts herein set forth before making final arrangements. The expectations of the earlier advocates of the industry have not been met, and the predictions of enthusiastic prophets have not been verified. It would be unwise and unjust to conceal the facts that the future of the sorghum-sugar industry is somewhat doubtful. The unsatisfactory condition is due to many causes. In the first place, the difficulties inherent in the plant itself have been constantly undervalued. The success of the industry has been based on the belief of the production of sorghum with high percentages of sucrose and small amount of reducing sugar and other impurities.

But the universal experience of practical manufacturers shows that the average constitution of the sorghum cane is far inferior to that just indicated. Taking the mean of several seasons as a sure basis of computation, it can now be said that the juices of sorghum as they come from the mill do not contain over 10 per cent. of sucrose, while the percentage of other solids in solution is at least 4.

It is needless to say to a practical sugar-maker that the working of such a juice is one of extreme difficulty, and the output of sugar necessarily small.

The working of sorghum juices will be found as difficult as those of beets, and true success cannot be hoped for until the processes used for the one are as complete and scientific as for the other. It is not meant by this that the processes and machinery are to be identical.

The chemical as well as mechanical treatment of the two kinds of juice will doubtless differ in many respects. And this leads to the consideration of the third difficulty, viz, the chemical treatment of sorghum juice. It has taken nearly three-quarters of a century to develop the chemistry of the beet-sugar process, and even now the progress in this direction is great. The chemistry of the sorghum-sugar process is scarcely yet a science. It is only an imitation of what has been done in other fields of work. Sorghum will have to develop a chemistry of its own. This will not be the work of a day or a year, but it will be accomplished sooner or later.

Careful study of climate and soil, joined with experience, will gradually locate those areas most favorable to the growth of this plant and its manufacture.

This is an all-important point in the problem, and is now occupying seriously the attention of the thoughtful advocates of the sorghum-sugar industry. One thing is already clear, *i. e.*, that the area of successful sorghum culture is not nearly so extensive as it was thought to be a few years ago. I would urge a further investigation in this direction as a work peculiarly within the province of the Department, and one which would prove of immense benefit to the country. Five million acres of land, suitable to the purpose, will produce all the sugar required for this country for several years to come. It is therefore certain that the sugar industry will be confined to the most favorable localities. If a thorough, scientific study of all the soil and climatic conditions does not point out this region, bitter experience and the loss of hundreds of millions of dollars will gradually fix its boundaries. Last of all, the

sorghum industry has suffered from the general depression which has been felt by the sugar industry of the entire world. Low prices have caused loss where every other condition has been favorable. It is hardly probable that the price of sugar will rise again to its maximum of the years past. Only war, pestilence, or disaster would produce this effect. It is best, therefore, for the sugar-grower to accept the present price as final and make his arrangements accordingly. But low prices will produce increased consumption, and thus, even with a smaller profit, the sugar-grower, by increased production, may find his business reasonably remunerative, if not as enriching as before. The sorghum-sugar grower will be injured or benefited with the growers of other kinds of sugar by these economic forces. Hence there should be no enmity between the grower of the sorghum, the sugar-beet, and the sugar cane, but all should work in harmony for the general good.

It is true the present outlook is discouraging. But discouragement is not defeat. The time has now come for solid, energetic work. Science and practice must join improved agriculture, and all together can accomplish what neither alone would ever be able to achieve. It is not wise to promise too much, but this Division would fall short of its duty were it either to suppress the discouraging reports of this industry or fail to recognize the possiblity of its success. The future depends on the persistence and wisdom of the advocates of sorghum. The problem they have to solve is a most difficult one, but its solution is not impossible.

It must be confessed finally that the chief object of this last series of experiments, viz, to place the industry where private capital would see its way clear to its extension over a large area, has not been attained.

It is now seen that much of what has been done is useless, and were the work to be gone over again these necessary mistakes of a first attempt would be avoided. Time, labor, and money could be saved.

What encouragement is just is offered to those who are willing to take up this work here and extend it.

The great difficulties in the way of extracting the sugar from the cane have been removed. The fact that sorghum, in certain circumstances, becomes a fine-sugar producing plant has been incontestably established. A suitable soil and climate have been found for growing the crop and manufacturing the sugar. Remaining difficulties in the way of success have been fairly and candidly pointed out.

Since the present appropriation was made for continuing and concluding these experiments, I consider that my connection with the development of the industry has ended. I leave the work with only one regret, and that is that the future of the sorghum-sugar industry is still in doubt.

EXPERIMENTS WITH SUGAR CANE.

On the 1st of October I received instructions from you to purchase a few tons of sugar cane in Louisiana and make some experiments with it at Fort Scott.

The cane was cut early in the season, viz, October 25 to 30, and was brought as quickly as possible to the factory.

CUTTING-MACHINE.

The cutters which worked so poorly with sorghum did well with sugar cane, and no trouble whatever was experienced in producing chips suitable to diffusion and at the rate of 6 tons per hour.

CHIP-ELEVATOR.

The same trouble was experienced with the elevator that we had had to contend with so long with sorghum, and to an increased ex-

tent. The chips being heavier than sorghum easily overweighted the elevator and caused it to clog. Considerable delay was caused by these annoyances.

THE DIFFUSION.

It was found at once that the temperature used for the diffusion of sorghum, viz, 70° C., was entirely too low to effect the extraction of sugar from sugar cane.

The temperature was gradually raised to 90° C. before a satisfactory extraction was obtained. The chips lying closer together in the cell caused the circulation of the liquid in the battery to take place more slowly. It was clearly evident that the pressure afforded by the feed-tank of the battery, viz, two-thirds of an atmosphere, is not great enough to work a battery rapidly when twelve cells are under pressure.

On November 6, all the cane having arrived and a preliminary trial having been made, the second trial was made. The experience of the first attempt had shown how the great loss of sugar in the chips, especially in the beginning, might be avoided. The second run was, therefore, made with an initial temperature of nearly 90° C. The quantity of juice withdrawn at each time was also increased by 100 liters.

Weight of cane used.—The weight of cane used in the second trial was 83.25 tons.

ANALYSES OF THE CANES.

The samples of chips were taken as described before:

	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
First sample	15.06	11.30	1.89
Second sample	14.68	10.86	1.62
Third sample	14.93	10.46	1.66
Fourth sample	13.47	10.43	1.89
Fifth sample	14.59	10.62	1.88
Sixth sample	13.55	10.05	1.75
Means	14.38	10.62	1.78

ANALYSIS OF DIFFUSION JUICES.

The samples were taken as before described:

	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
First sample	10.11	7.33	1.18
Second sample	10.15	7.95	1.20
Third sample	10.08	7.15	1.17
Fourth sample	10.05	6.96	1.29
Fifth sample	9.83	7.03	1.29
Sixth sample	8.96	6.55	1.22
Means	9.86	7.16	1.23

EXHAUSTED CHIPS.

The samples were taken as described in the preliminary trial:

	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
First sample	1.56	.50	.12
Second sample	1.21	.38	.07
Third sample	1.11	.38	.10
Fourth sample	1.11	.37	.09
Fifth sample	1.06	.42	.10
Sixth sample	.77	.18	.05
Means	1.14	.37	.09

CARBONATATED JUICES.

The samples were taken in such a way as to represent the same body of juice corresponding to the same numbered samples of diffusion juice. Each carbonatation tank held three charges of diffusion juice. A measured sample after carbonatation was taken from each series of four tanks.

	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
First sample	10.11	7.27	1.09
Second sample	10.25	7.91	1.14
Third sample	10.14	7.25	1.11
Fourth sample	9.72	7.00	1.21
Fifth sample	9.72	7.10	1.22
Sixth sample	9.55	6.50	1.12
Means	9.92	7.17	1.15

SULPHURED JUICES.

The samples of sulphured juice were taken in a way to represent as nearly as possible the same body of juice as indicated by the corresponding numbers under carbonatated juice. Since, however, the juices after carbonatation had to fall into a receiving tank before being sent to the filter-presses, some mixing of the different bodies of juice was unavoidable.

Thus the analyses below are not strictly comparable with the same numbers under diffusion and carbonatated juices:

	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
First sample	9.88	7.68	1.09
Second sample	11.12	8.09	1.14
Third sample	10.35	7.39	1.23
Fourth sample	9.89	7.02	1.26
Fifth sample	10.15	6.93	1.28
Sixth sample	9.34	6.44	1.17
Means	10.12	7.18	1.20

SEMI-SIRUPS.

The semi-sirup from the juices was put in two tanks. Samples were taken from each tank:

	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
First sample	42.9	32.0	5.95
Second sample	41.9	30.8	6.45

The first sample represents the first third of the run, and the second sample the second two-thirds.

FIRST SUGARS MADE.

The *masse-cuite* stood in cars two days.

On drying it yielded	pounds..	11,185
The yield of "seconds" was	do....	805
Total weight produced	do....	11,990
Sugar per ton	do....	144
Sugar to weight of cane	per cent..	7.2

PERCENTAGE TOTAL SUGAR OBTAINED.

	Per cent.
The juice contained	10.62
And the cane	9.56
Percentage sucrose obtained	75.3

COMPOSITION OF THE FIRST SUGARS.

The sample was taken from each barrel as it was filled. The samples were all mixed well together and placed in a tight bottle, which was not opened until the sample for analysis was taken. It is therefore as fair a sample of the product made as could possibly be obtained. It gave of—

	Per cent.
Moisture	.73
Ash	.14
Glucose	.52
Undetermined	.61
Sucrose	98.00

Compare this result with the work on Magnolia plantation last year, as found in Bulletin No. 11, p. 26:

	Pounds.
Weight first sugars per ton	119
Weight second sugars per ton	29.75
Total first and second	148.75

	Per cent.
Percentage obtained	7.44
Sucrose in juice	12.11
Sucrose in cane	10.90
Percentage obtained	68.3
Sucrose in cane at Magnolia	10.90
Sucrose in cane at Fort Scott	9.56
Difference	1.34

The increase in the yield per ton at Magnolia, had the cane been worked by diffusion, would have been, therefore, 26.8 pounds.

The yield of seconds at Fort Scott was surprisingly low. The molasses as it came from the centrifugals was full of crystals. About one-third its volume of warm water was added to this molasses and the crystals all dissolved before boiling. This may have diminished the yield.

The "thirds" have been placed in cars and set away until next fall. The "thirds" fill 5 wagons, each containing 23 cubic feet, or in all 125 cubic feet, weighing approximately 10,000 pounds. Of this amount, 6,189 pounds are from the second run.

	Pounds.
The total product therefore is sugar	11,990
Thirds, *masse-cuite*	6,189
Total	18,179

Or 218.3 pounds per ton of cane worked. This is nearly 11 per cent. of the weight of cane used.

But calculated on the original *masse-cuite*, which filled 9 cars, there would have been $9 \times 23 = 207$ cubic feet, or 18,837 pounds $= 226$ pounds per ton, or 11.3 per cent.

But the method of reckoning the increased production which has just been used is not a fair one, since it rests on the assumption that the sucrose in each case is equally available. But a moment's consideration will show that this is not the case.

The term "available sugar" is not a precise one. It may have many interpretations. In France, for instance, the *rendement* is calculated by deducting from the total sucrose twice the glucose and from three to five times the ash. This is a good rule for beet sugar, but in cane juice the ash, being mostly calcium salts, is far less melassigenic than that of the beet juice, made up chiefly of potassium compounds.

Another method of calculating "available sugar" is to diminish the percentage of sucrose by the difference between it and all the other solids in solution. This method is apt, however, to give results too low. In this uncertainty the term "available sugar" should always be accompanied by an explanation of the manner of making the calculation.

The yield of sugar obtained at Fort Scott being the highest ever got from sugar cane may be taken as the true amount of "available sugar" until some better yields are reported.

Notice for a moment the relation of this yield to the respective quantities of sucrose and glucose present:

	Per cent.
Sucrose in juice	10.62
Sucrose in cane	9.56
Yield of sucrose	7.20
Difference between sucrose in cane and yield	2.36
Glucose in juice	1.78
Glucose in cane	1.60

Ratio of percentage of glucose to percentage of sucrose lost 1.5 nearly.

It appears, therefore, that the rational way to calculate "available sugar" when the quantities of sucrose and glucose in the canes are known is to diminish the percentage of sucrose by one and a half times the glucose.

Applying this method we have the following results:

AT FORT SCOTT.

Sucrose in cane	per cent..	9.56
One and a half times glucose in cane	do....	2.40
Theoretical available sugar	do...	7.16
Pounds per ton		143.2
Pounds per ton obtained		144

AT MAGNOLIA.

Sucrose in cane	per cent..	10.90
One and a half times glucose in cane	do....	1.38
Theoretical available sugar	do....	9.52
Pounds per ton		194.4
Pounds per ton obtained		148.75
Difference	pounds..	41.65

This shows in the most convincing manner that by the process of diffusion and carbonatation the yield of sugar from sugar cane can be increased fully 30 per cent. over the best milling and subsequent treatment of the juice which has ever been practiced in this or any other country.

If this be true of the best milling, it is easy to estimate the increase over the average milling of Louisiana. It is not extravagant to suppose that this increase will be fully 40 per cent.

But the problem may also be approached in another way. It has just been shown what the product would have been had the Fort Scott process been applied at Magnolia. It may now be asked, "What would have been the yield had the Magnolia process been applied at Fort Scott?"

The process used at Magnolia produced 148.75 pounds sugar from cane in which the available sugar was 190.4 pounds. The percentage of available sugar obtained was

$$148.75 \times 100 \div 190.4 = 78.1 \text{ per cent.}$$

The available sugar in the cane at Fort Scott was 7.16 per cent. Multiply this by .78 and the product, 5.58, will be the yield of sugar which the Magnolia process would have given at Fort Scott, or 111.6 pounds per ton. Deduct this from the quantity obtained, and the remainder will represent the increased yield, viz, 32.4 pounds. Thus, in whatever way the calculation is made, it is seen that the processes of diffusion and carbonatation give a largely increased yield.

Another important question which arises is this, "Does this increased yield come wholly from the increased extraction, or is it partly due to the method of purifying the juice?" I will try to give a rational answer to this question, based on the data of the analyses and the respective *rendements* give by the two processes.

The percentage of extraction at Magnolia was 78. Reckoning the juice at 90 per cent., the loss in juice was 12 per cent. The percentage of juice, and consequently of sugar extracted, was 86.6 per cent. The mean loss of sugar in the chips at Fort Scott was .38 per cent., and the quantity of sugar present was 9.56. The percentage of extraction was therefore 96 per cent. The gain in extraction by diffusion is therefore 9.4 per cent. It is thus evident that the large gain

in yield, as established at Fort Scott, cannot be due wholly to the increased extraction of the sugar. It must therefore be largely due to the processes of depuration employed.

The process of carbonatation tends to increase the yield of sugar in three ways:

(1) It diminishes the content of glucose. This diminution is small when the cold carbonatation as practiced at Fort Scott is used; yet, to at least once and a half its extent, it increases the yield of crystallized sugar.

(2) By the careful use of the process of carbonatation there is scarcely any loss of sugar. The only place where there can be any loss at all is in the press cakes, and when the desucration of these is properly attended to the total loss is trifling. The wasteful process of "skimming" is entirely abolished, and the increased yield is due to no mean extent to this truly economical proceeding.

(3) In addition to the two causes of increase already noted, and which are not sufficient to produce the large *rendement* obtained, must be mentioned a third, the action of the excess of lime and its precipitation by carbonic acid on the substances in the juice, which are truly melassigenic. Fully half of the total increase which the experiments have demonstrated is due to this cause. It is true the coefficient of purity of the juice does not seem to be much affected by the process, but it is evident that the treatment to which the juice is subjected increases in a marked degree the ability of the sugar to crystallize. This fact is most abundantly illustrated by the results obtained.

Not only this, but it is also evident that the proportion of first sugars to all others is largely increased by this method. This is a fact which may prove of considerable economic importance.

It thus appears that the yield of sugar would be greatly increased by the application of carbonatation to mill juices. Since a complete carbonatation outfit can be erected for about $4,000, it would be well if some planter or syndicate of planters should give the process a trial.

These facts are worthy of closer consideration, inasmuch as the process of carbonatation has been fiercely and maliciously assailed as one which destroys both sugar and molasses.

WEIGHT OF DIFFUSION JUICE COMPARED WITH WEIGHT OF CANE WORKED.

Number of cells filled, 83.

Weight chips in each cell = 83.25 ÷ 83 = 1.003 tons = 2,006 pounds.

Weight juice drawn from each cell of chips, 1,100 liters. Specific gravity 1.04=2,516.8 pounds.

The weight of normal juice in 2,006 pounds of cane is 1,805 pounds. The additional weight of water added by diffusion is 711.8 pounds.

The percentage of increase over normal juice 711.8 × 100 ÷ = 39.4 per cent. This increase represents what is often called the "dilution" of the juice. The quantity of water to be evaporated to produce a given quantity of sugar is therefore 39.4 per cent. greater for such a diffusion than for a normal mill juice. In practice this amount could easily be reduced to 25 per cent.

COMPOSITION OF PRESS CAKE.

The defecation and filtration of the juice from 83.25 tons of cane gave 197 press cakes.

The mean weight of these cakes was 24 pounds each, and the total weight 4,728 pounds. A sample of the cake taken directly from the press and dried contained of moisture 45.37 per cent. The total weight of dry matter obtained in the press cakes was, therefore, 2,582.9 pounds.

Analysis of the dried cake gave the following results:

	Per cent.
Albuminoids	9.585
Sucrose	Trace.
Glucose	Trace.
Other organic matter	17.45

QUANTITY OF LIME USED.

As is seen under sorghum experiments, it required 1.5 per cent. lime to produce a good filtration.

I felt sure that the juice from the sugar cane would not require as great a quantity. At the preliminary trial 1 per cent. of lime was used, and the cakes formed were perfect, firm, and hard.

In the second run only .75 per cent. of lime was used, and the cakes were equally as good. There is little occasion for using less lime than this, for with this quantity the carbonatations were easily finished in fifteen to twenty minutes.

COEFFICIENT OF PURITY IN SECOND TRIAL.

	Per cent.
Of the mill juices the coefficient was	73.8
Of the diffusion juices the coefficient was	72.6
Of the carbonatated juices the coefficient was	72.3
Of the sulphured juices the coefficient was	70.9
Of the first semi-sirup the coefficient was	74.6
Of the second semi-sirup the coefficient was	73.5

In both trials it was seen that the coefficient of purity was increased during the process of evaporation. This was doubtless caused by the precipitation of some of the lime salts held in solution by the juices.

DIFFICULTIES ENCOUNTERED.

A number of unfavorable conditions was encountered during the prosecution of the experiments. The water supply was from a stagnant pond. The water had been greatly improved by the application of lime a few days before the experiment was made, but it was still black and putrid, emitting a nauseating stench.

WATER FROM LAKE PARKINSON, FORT SCOTT, KANS.

The following table gives the results of the analysis of the sample of the pond water from the Parkinson Sugar Works, Fort Scott, Kans., taken October 13, 1886, and of a sample of Potomac water taken from the laboratory faucets November 19, 1886, for comparison.

Analysis of Lake Parkinson and Potomac waters.

[Grains per United States gallon of 231 cubic inches.]

Found.	Lake Parkinson. Water dark, with a strong cheese smell.	Potomac River. Water clear, no odor.
Na	3.569	1.038
Cl	1.189	.169
K	2.280	.128
SO_3	.120	.389
CaO	10.142	2.321
MgO	1.330	.412
SiO_2	2.001	.449
$Fe_2O_3+Al_2O_3$	.609	.184
Cu	.041	....
Volatile and organic matter	20.761	.093
Probably combined as:		
NaCl	1.961	.278
K_2SO_4	.261	.285
Na_2CO_3	6.442	1.796
Na_2SO_4	....	.458
K_2CO_3	3.821	....
$CaCO_3$	18.106	4.144
$MgCO_3$	2.793	.865
SiO_2	2.001	.449
$Fe_2O_3+Al_2O_3$	.609	.184
Cu	.041	....
Volatile and organic matter	20.761	.093
Total	56.796	8.552
Total solids, by evaporation	58.271	8.581

The sample of Potomac water was taken after a period of long-continued drought, and was unusually clear and free from all clay held in suspension.

The Parkinson water contained so much organic matter, that it was found impossible to estimate the free and albuminoid ammonia by the usual process, though a dilution of 1:1000 was tried.

The presence of copper in the water is remarkable, and probably exists in a state of combination with some organic acid.

The strike-pan used was quite unsuitable for boiling to grain. Its base was once the bottom of a much smaller pan, and a shelf several inches deep had been added to support the enlarged top. All the large steam-coils were above this shelf, and it took eight hours to bring the contents of the pan above this point. We had no sugar-boiler, but my assistant, Mr. G. L. Spencer, took charge of the pan and did remarkably well.

The sugar dried slowly in the centrifugals. These were not well set, and could not be run at a very high speed on account of shaking. It took nearly forty-eight hours with three machines to dry the sugar from the 83.25 tons.

This difficulty in drying was due either—

(1) To the process of diffusion; (2) to the process of carbonatation; (3) to the fine grain produced in boiling; (4) or to the poor quality of the cane.

Which one of these causes was most potent only future experiments will decide. I am not wise enough to place it, as has already been done by some premature critics, on one of them alone.

It seems most reasonable to suppose, however, that the poor quality of the cane and the extreme fineness of the crystals were the chief causes of the difficulty mentioned. The process of carbonatation has

been practiced for ten years in Java on mill juices and no complaint has ever been heard of difficulty in purging the sugar. With the fresh ripe canes of Louisiana worked promptly as they come from the field, and with the juice in the hands of an experienced sugar-boiler, I do not believe this difficulty would be encountered.

With the improvements in the process of carbonatation already pointed out in the discussion of the experiments with sorghum even better results may be expected.

BAGASSE.

The disposition of the exhausted chips is a question of great economic importance. Three uses appear to be possible: (1) For paper-stock; (2) for manure; (3) for fuel.

A good article of both wrapping and print paper can be made of the fiber of the cane. The economic discussion of this use, however, can only be properly given by a paper-maker.

The value of the bagasse for a manure is undoubtedly great. This problem has already been discussed in Bulletin No. 8, page 46.

By referring to the table of analyses of the chips it will be seen that with a small hand-mill 63.72 per cent. of water was extracted from the exhausted chips; on the same mill the percentage of extraction of the fresh chips was only 56.31 per cent. Thus in similar conditions the percentage of extraction with a given mill will be 7.31 per cent. higher for exhausted chips than for fresh canes. A mill, therefore, which will give a 78 per cent. extraction with cane will give 85 per cent. with exhausted chips.

The exhausted chips contained 90 per cent. water. Of this quantity 63.72 per cent. were extracted, leaving 26.28 per cent. water to 10 fiber.

A given quantity of the bagasse, therefore, contained 72.2 per cent. water and 27.8 per cent. fiber. A mill which would give 80 per cent. extraction with the exhausted chips would furnish a bagasse composed of equal parts of water and fiber, and this would prove a most exellent fuel.

The power required to drive such a mill would only be about one-third as great as for the same weight of cane.

The attempts to dry cane chips on the presses used for beet cuttings have proved failures, but the experiments made at Fort Scott show that a properly arranged mill will solve this problem at once.

It must be remembered, however, that even if the exhausted chips be made as dry as ordinary mill bagasse, they will not afford so much fuel. They contain little but the fiber of the cane, while mill bagasse still holds large quantities of sugar, which itself is a most excellent fuel.

The loss of the bagasse as a fuel has been the principal objection to the introduction of diffusion into tropical sugar districts.

It now remains to continue these experiments at some favorable station in Louisiana. Such a station should be provided with a first-class double or triple effect and other apparatus for evaporating the juice and separating the sugar.

It should also be a station purely experimental. The attempt to carry on experiments and manufacture a large crop of cane at the same time would only end in the disastrous manner, economically considered, of the sorghum work just concluded at Fort Scott.

These experiments can only be successful at a station where perfect freedom of action and plenty of time are at the director's command.

It is the proper province of the Department to demonstrate in Louisiana just how much increase in sugar yield can be produced by the application of the methods named in the act making the appropriations. This done, and all the processes for doing it accurately pointed out and logically discussed, it will not be difficult for the intelligent planter to determine the economic value of the new methods.

To this task should be brought a careful study of the chemical problems involved and the best apparatus which this country or Europe can afford. From this task should be eliminated all prejudices for or against any particular process, and especially all tendency to misrepresent or misinterpret facts.

At least the Department will be able in subsequent experiments to show the Southern sugar-raiser whether the promises which these preliminary experiments have made shall really be performed, or whether the practice of the process of diffusion for sugar cane is a mistake and the prospects it has offered of aiding the sugar industry a delusion.

It is certain that with the fierce rivalry between the European beet and the tropical cane industry, producing an enormous surplus of sugar and sending the prices down almost below the cost of production, the indigenous sugar-cane industry of this country will languish unless the Department of Agriculture be able to lead it into a life of renewed vigor.

EXPERIMENTS IN THE MANUFACTURE OF SUGAR AT MAGNOLIA STATION, LAWRENCE, LA.

By Guilford L. Spencer.

The manufacturing season at Magnolia commenced November 7, 1886, and ended December 20. This completes the third season's work of the Department at this station.

I shall give in as few words as possible a brief comparison of the growing seasons of the past three years.

In 1884 the weather was favorable until the 1st of June; then followed a period of very wet weather, lasting until August, which was a very dry month. The conditions in September and October were favorable to the maturing of the cane. During the rolling season heavy rains were frequent.

SEASON OF 1885.

The early part of this season was exceptionally wet. From April 1 to July 1 the rainfall was limited to but three or four showers; in August and September the rains were frequent and heavy; from October until the end of the season the weather was exceptionally dry and cool, the mean temperature being considerably below that of 1884. In September the cane was prostrated by a heavy wind-storm.

SEASON OF 1886.

February, March, and April were cold and wet, consequently the cane obtained a late start. May was dry and cool. June and July so wet that it was impossible to properly cultivate the cane. August was dry and exceedingly hot; September and through the rolling season the weather was very dry. The dry weather probably saved the cane from being blown down in the severe storm of October, when the lower coast of the Mississippi, near Pointe à la Hache, was

so badly damaged. There was a killing freeze November 17. This is the earliest freeze, with one exception, noted in the plantation records, extending over a long period of years. December was cold; ice formed several times.

It may be seen from the above statements that these three seasons differed very materially from one another. That of 1884 might be considered very favorable. The tonnage was fair and the cane rich. In 1885 the conditions were also favorable, with the exception of the wet weather in September and the damage by the wind-storm. The tonnage was large, but the proportion of sucrose low and the glucose high.

In January, 1886, there was a severe freeze, perhaps the most severe on record in Louisiana. At the time of this freeze it was feared that the stubble had been damaged by the frost, but such did not prove to be the case. It is the custom at Magnolia to burn the trash in the fields soon after the cane is all harvested. There is a general impression among planters that this exposes the stubble to danger from frost. The experience of the past season demonstrates that such is not the case.

The tonnage this season has been unusually small, but the cane has been a little richer in available sucrose than at any time since this station was established.

In comparing the work of the sugar-house it is probably better to compare this season's work with that of 1884–'85. The same grades of sugars were made these seasons.

The yield per acre in 1885–1886 was 2,988 pounds of first, second, and third sugars. In 1886 the yield of first and second sugars was 1,963 pounds. In 1886 a decrease of 6.66 tons of cane per acre resulted in a decrease of 1,024 pounds of sugar per acre.

The yield of sugar per ton of cane the past season has been exceedingly satisfactory, but nevertheless it is anticipated that a few changes in working of the house will materially increase the output of sugar.

This season only first and second sugars were made. The firsts graded as "choice off white." The yield of first sugar would have been larger had it been possible to boil the *masse-cuite* stiffer, but the strike-valve of the pan would not admit of this.

As large a proportion of sugar as possible should be obtained in the firsts, not only on account of the higher price of first sugars, but because less sugar is left to be reboiled for lower grades, and consequently the loss from inversion is diminished.

IMPROVEMENTS IN THE SUGAR-HOUSE AND PLANTATION.

Very few changes were made in the house, and those only for improving the work of machinery already in place. The tanks for skimming were provided with a better arrangement for decanting the clear juice. The lowest outlets from these tanks are about 2 inches above the bottoms. They should be provided with outlets so located that the tanks could be drained, effecting quite a saving in sugar at an inappreciable expense.

Perhaps the most important improvement was in the work of the double effect. The substitution of a larger sweet-water pump enabled it to concentrate all the juice and obviated the necessity of employing an open pan.

Among other improvements in progress at Magnolia, the most important is a better system of drainage. The entire estate is being tile-

drained. This improvement will necessitate an expenditure of about $40,000.

Aside from the benefits to be derived from better drainage, there will be important advantages gained from closing the ditches. The amount of tillable land will be increased about 70 acres; the large annual expenditure for keeping the ditches and quarter-drains open will be stopped; the cultivation will be easier and less expensive, and the steam-plows can be handled at a considerably better advantage.

Should the work of the station be continued, very interesting and valuable data can be obtained next season.

ACCIDENTS TO THE MILLS.

The mills were stopped several times on account of small pieces of iron getting into them. Some of this iron passed through the shredder; other pieces were introduced after the cane left the shredder. It was evident that the iron was put into the carriers maliciously. This trouble finally culminated in the breaking of the shell of one of the rolls of the supplemental mill. A few changes were made in the disposition of the men detailed for work at the mills, and the work was finished without further accident than the breaking of three couplings.

The average extraction, and consequently the yield of sugar, would have been larger had the supplemental mill not been damaged.

THE BAGASSE-BURNER AND THE CONSUMPTION OF FUEL.

The burner, as improved last season, worked very satisfactorily. The consumption of coal was reduced very considerably.

The amount of coal consumed was determined by weighing it for half the season and basing the total consumption on these data. The result was as follows:

Coal consumed in 21 days = 436,338 pounds, or 20,778 pounds per day. From the time the fires were kindled until all the work was finished was 45 days; hence the total coal consumption was $45 \times 20,778 = 935,010$ pounds. The total weight of sugar made was 1,159,768 pounds; therefore the consumption of coal per 1,000 pounds of sugar was 806 pounds, or 4.42 barrels.

This house could be worked almost entirely without coal if the following improvements were made:

(1) Substitute copper coils for the iron ones in the clarifiers.

(2) Introduce a condenser, employing juice to condense the vapors from the double effect. An illustration of such apparatus is given opposite page 114, Bulletin No. 5, and is termed a *Calorisateur à contre courant.*

The question of economical engines is of less importance, since the exhaust steam is employed for evaporation.

COMPOSITION OF THE JUICE.

The chemical work at Magnolia Station was not begun until the 24th November. Although the work of the sugar-house nominally commenced November 7, but little cane was rolled before the 13th. The analyses, therefore, show the composition of the juice for all but eleven days of the season, in which time 2,113 tons of cane were rolled. This cane yielded 8 pounds less sugar per ton than the next 2,000 tons, consequently it is fair to presume that it contained less sucrose.

Table I shows the composition of the raw juices:

TABLE I.—*Analyses of juices.*

[When two analyses are given the same date, the first was sampled in the morning and the second in the afternoon.]

Date.	Number.	Degree Baumé.	Degree Brix, Total solids.	Specific gravity.	Sucrose.	Reducing sugars.	Albuminoids.	Albuminoid, per cent. sucrose.	Coefficient of purity.
1886.			*Per ct.*		*Per ct.*	*P. ct.*	*Per ct.*		
November 24	1	9.4	17	1.0700	13.50	.57	.2438	1.80	79.41
24	2	9.	16.3	1.0669	12.84	.66	.2063	1.61	78.77
25	3	9.2	16.66	1.0682	13.90	.82	.0625	.45	83.43
26	4	8.6	15.55	1.0634	12.28	.87	.1625	1.32	78.97
26	5	9.1	16.37	1.0674	13.60	.74	.0875	.64	83.08
27	6	8.6	15.55	1.0634	12.00	.73	.2250	1.88	77.17
28	7	9.5	17.21	1.0709	14.36	.46	.1500	1.04	83.43
28	8	9.5	17.07	1.0704	14.21	.49	.1625	1.14	83.24
29	9	9.9	17.88	1.0739	15.04	.43	.1375	.91	84.11
29	10	9.6	17.33	1.0713	14.54	.53	......	......	83.90
30	11	9.4	16.90	1.0695	13.91	.46	.1188	.85	82.30
30	12	9.2	16.69	1.0687	14.21	.39	......	......	85.14
December 1	13	9.5	17.14	1.0709	13.95	.68	.1375	.99	81.29
1	14	9.2	16.63	1.0682	13.97	.55	......	......	84.00
2	15	8.9	16.00	1.0656	14.04	.60	.1313	.94	87.68
2	16	9.	16.29	1.0669	13.00	.58	.1250	.96	79.80
3	17	9.	16.23	1.0665	13.76	.69	.1375	1.00	84.78
3	18	9.	16.17	1.0665	13.01	.77	.1500	1.15	80.45
4	19	8.6	15.59	1.0639	12.75	.49	.1813	1.42	81.78
4	20	8.8	15.78	1.0647	13.12	.60	......	......	83.14
5	21	8.9	16.05	1.0656	13.33	.51	.2063	1.55	83.05
6	22	8.9	16.16	1.0660	13.90	......	......	......	86.01
6	23	8.6	15.46	1.0634	12.89	......	......	......	83.39
7	24	8.2	14.76	1.0604	11.67	......	.2813	2.41	79.06
8	25	8.5	15.36	1.0630	12.88	.58	......	......	83.85
8	26	8.8	15.89	1.0652	13.63	......	......	......	85.77
9	27	9.5	17.07	1.0704	14.97	.72	......	......	87.69
10	28	8.6	15.47	1.0634	13.19	.48	.1313	.99	85.26
10	29	8.9	16.11	1.0660	13.84	.45	.2063	1.49	85.90
11	30	8.9	16.09	1.0660	13.45	.46	.2000	1.49	83.59
11	31	9.	16.17	1.0665	13.70	.46	.2000	1.46	84.72
12	32	8.5	15.39	1.0630	12.32	.91	.1500	1.22	80.05
12	23	8.6	15.47	1.0634	13.56	.64	.1063	.79	87.65
13	34	8.5	15.40	1.0630	12.91	.72	.1625	1.26	83.83
13	35	8.6	15.57	1.0639	12.97	.51	.3000	2.31	83.30
14	36	8.5	15.27	1.0629	13.04	.51	.2500	1.92	85.39
14	37	8.8	15.87	1.0652	12.92	.72	......	......	81.41
15	38	9.1	16.73	1.0674	13.77	.55	.1938	1.41	83.62
15	39	9.	16.18	1.0665	13.85	.58	.1313	.95	85.59
16	40	9.2	16.62	1.0682	14.87	.55	.1563	1.05	89.47
16	41	9.1	16.46	1.0678	14.81	.47	.1250	.84	89.97
17	42	9.	16.19	1.0665	13.76	.60	.1625	1.18	84.99
17	43	9.2	16.69	1.0687	14.34	.52	.1313	.91	85.91
18	44	9.	16.29	1.0669	13.60	.55	.1625	1.19	83.42
18	45	8.4	15.19	1.0621	12.50	......	......	......	82.29
19	46	8.5	15.39	1.0630	12.78	......	......	......	82.06
Means	......	9.	16.20	1.0665	13.50	.61	.1669	1.24	83.33
Maxima	......	9.9	17.88	1.0739	15.04	.91	.3000	2.41	89.47
Minima	......	8.2	14.76	1.0604	11.67	.39	.0625	.45	77.17

RÉSUMÉ SHOWING THE MEAN COMPOSITION OF THE RAW JUICE FOR THE CAMPAIGN OF 1886.

[November 24 to December 20.]

Total number of analyses		46
Specific gravity		1.0665
Degree Baumé		9.
Degree Brix (per cent. total solids)		16.20
Sucrose	per cent.	13.50
Reducing sugars (glucose, &c.)	do.	.61
Albuminoids	do.	.1669
Albuminoids (per cent. sucrose)		1.24
Coefficient of purity		83.33

Maxima.

Specific gravity	1.0739
Degree Baumé	9.9
Degree Brix (per cent. total solids)	17.88
Sucrose .... per cent.	15.04
Reducing sugars (glucose, &c.) .... do.	.91
Albuminoids .... do.	.3000
Albuminoids (per cent. sucrose)	2.41
Coefficient of purity	89.47

Minima.

Specific gravity	1.0604
Degree Baumé	8.2
Degree Brix (per cent. total solids)	14.76
Sucrose .... per cent.	11.67
Reducing sugars (glucose, &c.) .... do.	.39
Albuminoids .... do.	.0625
Albuminoids (per cent. sucrose)	.45
Coefficient of purity	77.17

COMPARISON OF RAW AND CLARIFIED JUICES.

In the following table analyses of the raw juices are only given for those days when the clarified juices were also examined:

TABLE II.—*Comparison of raw and clarified juices.*

[When two analyses are given the same date, the first was sampled in the morning and the second in the afternoon.]

Date.	Numbers.	Raw juices.						Clarified juices.					
		Degree Baumé.	Degree Brix.	Sucrose.	Reducing sugars.	Albuminoid, per cent. sucrose.	Coefficient of purity.	Degree Baumé.	Degree Brix.	Sucrose.	Reducing sugars.	Albuminoid, per cent. sucrose.	Coefficient of purity.
1886.				*Per ct.*	*P.ct.*					*Per ct.*	*P.ct.*		
November 25	3	9.2	16.66	13.90	.82	.....	83.43	10.2	18.37	14.92	.85	....	81.22
26	4	8.6	15.55	12.28	.87	1.32	78.97	9.9	17.87	14.82	.79	.51	82.93
26	5	9.1	16.37	13.60	.74	.64	83.08	9.6	17.34	14.38	.79	.52	82.93
27	6	8.6	15.55	12.00	.73	1.88	77.17	9.1	16.37	12.95	.82	1.01	79.11
28	7	9.5	17.21	14.36	.46	1.04	83.43	9.3	17.79	14.98	.61	.71	84.20
28	8	9.5	17.07	14.21	.49	1.14	83.24	10.0	18.04	15.17	.50	.74	84.09
29	9	9.9	17.88	15.04	.43	.91	84.11	10.5	18.98	16.01	.68	.47	84.35
29	10	9.6	17.33	14.54	.53	.....	83.90	10.1	18.19	15.71	.53	....	86.37
30	11	9.4	16.90	13.91	.46	.85	32.30	10.3	18.70	16.04	.61	.55	85.78
30	12	9.2	16.69	14.21	.39	.....	85.14	9.7	17.47	14.63	.46	....	83.74
December 1	13	9.5	17.14	13.95	.68	.99	81.39	9.7	17.46	14.11	.84	.71	80.81
1	14	9.2	16.63	13.97	.55	.....	84.00	9.7	17.59	14.59	.42	....	82.94
2	15	8.9	16.00	14.04	.60	.95	87.75	9.9	17.87	14.27	.46	.88	79.85
2	16	9.0	16.29	13.00	.58	.96	79.80	9.4	16.89	14.85	.55	.58	87.92
3	17	9.0	16.23	13.76	.69	1.00	84.78	9.6	17.27	14.56	.43	.69	84.31
3	18	9.0	16.17	13.01	.77	1.15	80.45	9.7	17.47	14.86	.71	.59	85.06
4	19	8.6	15.59	12.75	.49	1.42	81.78	9.9	17.79	14.64	.49	.56	82.29
4	20	8.8	15.78	13.12	.60	.....	83.14	9.4	16.89	14.18	.46	....	83.96
9	27	9.5	17.07	14.97	.72	.....	87.69	9.1	16.40	14.20	.60	....	86.59
10	28	8.6	15.47	13.19	.48	.....	85.26	9.5	17.07	14.57	.62	....	85.35
10	29	8.9	16.11	13.84	.45	1.49	85.90	9.5	17.19	15.07	.49	.87	87.67
11	30	8.9	16.09	13.45	.46	1.49	83.59	9.6	17.39	15.15	.50	.83	87.11
12	32	8.5	15.39	12.32	.91	1.22	80.05	9.5	17.09	14.56	.70	.86	85.20
12	33	8.6	15.47	13.56	.64	.....	87.65	8.8	15.87	13.48	.62	....	84.94
13	34	8.5	15.40	12.91	.72	1.26	83.83	9.0	16.31	14.07	.65	.98	86.14
13	35	8.6	15.57	12.97	.51	2.31	83.30	9.6	17.39	15.09	.63	.79	86.77
14	36	8.5	15.27	13.04	.51	1.92	85.39	9.7	17.47	14.94	.50	1.09	85.52
14	37	8.8	15.87	12.92	.72	.....	81.41	9.4	16.94	14.31	.48	....	84.47
15	38	9.1	16.43	13.74	.55	.....	83.62	9.6	17.33	14.91	.62	....	86.04
15	39	9.0	16.18	13.85	.58	1.26	85.59	10.5	18.93	16.35	.43	.95	86.37
17	42	9.0	16.19	13.76	.60	1.18	84.99	10.1	18.17	15.91	.45	.63	87.56
17	43	9.2	16.69	14.34	.52	.91	85.91	9.7	17.47	15.23	.55	.57	87.18
18	44	9.0	16.29	13.60	.55	1.19	83.48	9.4	17.00	14.90	.64	.59	87.65
Means	....	9.0	16.26	13.58	.60	1.24	83.52	9.7	17.46	14.89	.59	.72	84.76

The increase in the coefficient of purity, as shown by Table II, was 1.24. There was but little change in the relative proportions of sucrose and reducing sugars. In the raw juice the average quantity of reducing sugars per cent. sucrose was 4.41; after clarification this proportion was reduced to 3.98. This slight reduction was probably due to the formation of a glucosate of lime, which was subsequently decomposed, leaving the products of the decomposition in solution.

In order to render the percentages of albuminoids more readily comparable they have been expressed in terms of the sucrose. To obtain the actual percentages of albuminoids based on the weight of the juice, multiply the percentage of sucrose by the number given in the column marked albuminoids percentage of sucrose.

In the raw juice the albuminoids per centages sucrose were 1.24 and in the clarified juice .72, showing that 58 per cent. of the total albuminoids were still retained by the juice. In 1884 the processes of defecation and clarification removed 45.71 per cent. of the total abuminoids; in 1885–1886, 45.01; and in 1886, 41.93.

COMPARISON OF RAW, CLARIFIED, AND FILTERED JUICES AND FILTERED SIRUP.

Analyses were conducted for a period of sixteen days, to determine the effect of the filtration through animal charcoal on the juice. These analyses are given in Table III.

TABLE III.—*Comparison of raw juices, clarified juices, filtered juices, and filtered sirups for a period of sixteen days.*

Date.	Number.	Raw juices. Degree Baumé.	Degree Brix.	Sucrose.	Reducing sugars.	Coefficient of purity.	Clarified juices. Degree Baumé.	Degree Brix.	Sucrose.	Reducing sugars.	Coefficient of purity.
1886.				*Per ct.*	*Per ct.*				*Per ct.*	*Per ct.*	
November 25	3	9.2	16.66	13.90	.82	83.43	10.2	18.37	14.92	.85	81.22
26	4	8.6	15.55	12.28	.87	78.97	9.9	17.87	14.82	.79	82.93
26	5	9.1	16.37	13.60	.74	83.08	9.6	17.34	14.38	.79	82.93
27	6	8.6	15.55	12.00	.73	77.17	9.1	16.37	12.95	.82	79.11
28	7	9.5	17.21	14.36	.46	83.43	9.3	17.79	14.98	.61	84.20
28	8	9.5	17.07	14.21	.49	83.24	10.0	18.04	15.17	.50	84.09
29	9	9.9	17.88	15.04	.43	84.11	10.5	18.98	16.01	.68	84.35
29	10	9.6	17.33	14.54	.53	83.90	10.1	18.19	15.71	.53	86.37
30	11	9.4	16.90	13.91	.46	82.30	10.3	18.70	16.04	.61	85.78
30	12	9.2	16.69	14.21	.39	85.14	9.7	17.47	14.63	.46	83.74
December 1	13	9.5	17.14	13.95	.68	81.39	9.7	17.46	14.11	.84	80.81
2	15	8.9	16.00	14.04	.60	87.75	9.9	17.87	14.27	.46	79.85
2	16	9.0	16.29	13.00	.58	79.80	9.4	16.89	14.85	.55	87.92
3	17	9.0	16.23	13.76	.69	84.78	9.6	17.27	14.56	.43	84.31
4	19	8.6	15.59	12.75	.49	81.78	9.9	17.79	14.64	.49	82.29
4	20	8.8	15.78	13.12	.60	83.14	9.4	16.89	14.18	.46	83.96
Means	....	9.1	16.52	13.67	.60	82.75	9.7	17.64	14.76	.62	83.62

TABLE III.—*Comparison of raw juices, clarified juices, &c.*—Continued.

Date.	Number.	Filtered juices.					Filtered sirups.				
		Degree Baumé.	Degree Brix.	Sucrose.	Reducing sugars.	Coefficient of purity.	Degree Baumé.	Degree Brix.	Sucrose.	Reducing sugars.	Coefficient of purity.
1886.				*Per ct.*	*Per ct.*				*Per ct.*	*Per ct.*	
November 25	3	9.0	16.17	12.48	.61	77.18	24.3	44.53	36.10	1.88	81.07
26	4	9.8	17.67	14.44	.77	82.86	23.4	42.79	35.93	2.29	83.97
26	5	9.2	16.61	13.71	.77	82.54	21.7	39.56	33.22	2.35	83.97
27	6	9.5	17.10	14.28	.89	83.51	22.3	40.70	33.56	2.61	82.46
28	7	9.6	17.33	13.60	.87	78.48	23.3	42.59	34.84	3.00	81.80
28	8	10.6	19.14	16.19	.60	84.59	22.6	41.36	33.01	2.19	79.81
29	9	10.2	18.58	15.34	.48	82.56	19.8	36.09	28.00	1.67	77.58
29	10	10.7	19.29	16.24	.55	84.19	23.6	43.15	36.10	1.96	83.66
30	11	12.3	22.22	18.52	.67	83.35	23.4	42.92	35.75	1.90	83.29
30	12	10.2	18.37	15.27	.44	83.12	23.7	43.40	36.54	1.88	83.96
December 1	13	10.7	19.39	15.63	.66	80.61	23.6	43.22	35.49	1.67	82.11
2	15	9.7	17.47	14.20	.51	81.28	21.4	39.10	32.58	1.98	83.32
2	16	9.4	16.89	14.45	.62	84.96	24.8	45.38	37.23	1.65	82.04
3	17	10.6	19.07	14.95	.70	78.40	24.1	44.10	36.24	1.70	84.44
4	19	9.5	17.19	14.56	.58	84.70	24.3	44.60	36.91	1.48	82.76
4	20	9.1	16.49	14.08	.44	85.26	20.8	38.00	31.80	1.64	83.68
Means	....	10.0	18.06	14.87	.64	82.14	23.0	41.97	34.58	2.00	82.39

The results of these analyses are not surprising when we conside the quality of the bone-black used. Mr. O. B. Stillman, a Boston refiner, examined this char, and pronounced it to be in a very bad condition. It weighed nearly 70 pounds to the cubic foot. This is nearly twenty pounds heavier than good char should weigh.

The decolorizing properties of this bone-black were good, but as it was already laden with impurities it did not improve the purity of the juice, but, on the contrary, reduced it. This was due to the impurities in the charcoal being redissolved.

The sirups, being heavier and already nearly saturated with soluble matter, yield their impurities more readily to the action of the bone-black and are improved in purity. Reference to the first* report of this station giving analyses of raw and filtered juices will show this same result. The charcoal in use at that time was even worse than last season.

I do not believe that the benefit from the mechanical filtration and the decolorization will balance the damage to the juice resulting from the use of spent bone-black.

THE FILTER-PRESSES.

The use of the filter-presses was continued this season with even greater success than in 1885 and 1886.

Very few analyses were made of the press cakes, except to determine loss of sucrose. However, the few analyses that were made are presented in the following table.

*Bulletin No. 5, p. 49.

TABLE IV.—*Analyses of press cakes.*

Date.	Sucrose.
1886.	*Per cent.*
November 30	7.40
December 1	7.24
December 3	7.34
December 4	8.06
Means	7.51

No record was kept in house of the quantity of juice recovered by the presses. In fact it would be quite difficult to determine just the proportion of the juice flowing from the presses that would be lost in ordinary work.

This season we found it necessary to empty one press once for every 2,889 gallons of juice expressed by the mills. The total amount of juice was 1,271,205 gallons, hence the number of presses of press-cake was 1,271,205÷2,889=440. The average weight of the press-cake per press was 330 pounds, 330×440=145,200 pounds of press-cake for the entire season. The amount of press-cake per ton of cane was 20.15 pounds.

In the work with the experimental* press in 1884, on thoroughly drained "blanket" scums, the yield of juice was 80 per cent. The average skimmings and settlings after long standing and decantation of the clear juice are much thinner than the blanket, and would yield from 85 to 90 per cent. juice by filter pressing. In order to under rather than over estimate the work of the presses, I will base my estimates on the actual yield obtained with the small experimental press. It may be well to state here that the work on a small scale was no better than with the large presses.

On the above basis the press cake forms 20 per cent. of the total weight of skimmings filtered; hence 145,200÷20×100=726,000, the total number of pounds of skimmings. These figures show that even on a low estimate 6½ per cent. of the juice is usually lost in the skimmings.

As the presses save at least 80 per cent. of this, the saving of juice at Magnolia this season was 580,000 pounds.

As I have repeatedly stated, I consider this estimate a very low one. I have no doubt but that carefully conducted experiments would show a saving of 970,000 pounds of juice. With the filter-press arrangement at Magnolia it is impossible to keep a separate account of juice recovered.

COMMERCIAL VALUE OF PRESS CAKE.

The average value of the press cake as given in last season's† report was \$10.64 per ton; the value of the nitrogen being \$4.35, and the phosphoric acid \$6.29.

Considering \$10.64 an average valuation, the press cake this season would be worth \$772.46.

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*Bulletin No. 5, p. 59.
†Bulletin No. 11, p. 16.

ANALYSIS OF SUGARS.

TABLE V.—*First sugars.*

Date.	Lot.	Sucrose.	Date.	Lot.	Sucrose.
1886.		*Per cent.*	1886.		*Per cent.*
November 22	13	99.0	December 6	27	99.1
24	14	99.3	9	28	98.7
24	15	98.8	9	29	98.0
25	16	99.1	10	30	98.2
26	17	99.3	12	31	98.8
28	18	99.5	13	32	99.0
28	19	98.5	15	33	99.2
29	20	97.8	17	34	98.7
30	21	98.9	17	35	99.2
December 1	22	98.9	19	36	98.9
2	23	98.8	20	37	98.8
3	24	97.8	21	38	98.9
4	25	97.8			
6	26	99.2	Mean	.....	98.78

TABLE VI.—*Second sugars.*

Date.	Lot.	Sucrose.	Date.	Lot.	Sucrose.
1886.		*Per cent.*	1886.		*Per cent.*
November 22	1	90.6	December 9	8	89.1
26	2	91.4	10	9	91.3
29	3	92.6	15	10	91.5
December 1	4	85.2	19	11	91.6
3	5	88.1	22	12	92.8
5	6	90.5	22	13	90.8
7	7	89.2			
			Mean	.....	90.3

The first sugars were "off white," the seconds yellow. But two sugars were made.

ANALYSES OF MOLASSES.

TABLE VII.—*Analyses of molasses from first sugars.*

[II. Molasses.]

Date.	Number of lot.	Degree Baumé.	Degree Brix.	Sucrose.	Reducing sugars.	Sucrose at 50° Brix or 27°.2 Baumé.	Reducing sugars at 50° Brix or 27°.2 Baumé.	Coefficient of purity.
1886.				*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
November 25	16	30.9	57.08	35.00	5.88	30.66	5.15	61.32
26	17	29.9	55.20	35.70	6.25	32.34	5.66	64.68
28	19	28.8	53.24	33.00	6.45	31.02	6.06	62.04
29	20	29.2	53.84	34.00	5.00	31.57	4.64	63.15
30	21	28.9	53.30	34.20	4.00	32.08	3.75	64.16
December 1	22	30.3	56.00	36.70	5.40	32.85	4.83	65.54
2	23	26.8	49.20	32.00	5.00	32.51	5.08	65.02
3	24	29.6	54.70	35.00	6.37	31.99	5.82	63.98
9	28	29.7	54.90	36.20	5.40	32.96	4.92	65.92
12	31	29.1	53.70	38.80	4.63	36.12	4.31	72.24
13	32	29.6	54.70	37.00	5.62	33.82	5.14	67.63
15	33	29.1	53.70	37.10	4.83	34.54	4.49	69.08
17	34	30.1	55.50	39.80	4.83	35.86	4.35	71.72
17	35	30.1	55.50	38.50	4.44	34.69	4.00	69.38
19	36	29.5	54.50	38.40	3.97	35.23	3.64	70.46
20	37	28.7	52.80	33.70	5.71	31.91	5.40	63.83
Means	....	29.4	54.24	35.94	5.24	33.13	4.83	66.26

TABLE VIII.—*Analysis of molasses from second sugars.*

[III. Molasses.]

Date.	Lot.	Degree Baumé.	Degree Brix.	Sucrose, single polarization.	Sucrose, double polarization.	Reducing sugars.	Sucrose, single polarization at 76° Brix or 40°.3 Baumé.	Sucrose, double polarization at 76° Brix or 40°.3 Baumé.	Reducing sugars at 76° Brix or 40°.3 Baumé.	Coefficient of purity (based on single polarization).
1886.				*Per ct.*	*Per ct*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
November 26	1	40.8	76.92	32.80	39.90	19.75	32.41	39.42	19.51	42.64
26	2	40.3	75.92	32.30	40.07	19.60	32.46	40.20	19.67	42.71
December 2	3	41.5	78.51	33.40	41.21	13.90	32.23	39.78	13.41	42.41
2	4	40.5	76.41	32.80	40.39	13.15	32.66	40.21	13.09	42.97
3	5	40.6	76.43	32.90	40.62	13.90	32.75	40.44	13.84	43.09
7	7	34.8	64.85	28.80	....	11.42	33.71	....	13.36	44.35
9	8	40.1	75.48	31.20	39.08	13.30	31.30	39.24	13.94	41.18
10	9	42.2	79.91	32.50	40.61	15.74	31.62	39.40	15.31	41.61
15	10	41.9	79.31	33.70	40.68	14.04	32.27	38.95	13.44	42.46
19	11	41.7	78.86	35.00	42.20	13.80	33.78	10.72	13.31	44.46
Means	....	40.5	76.26	32.54	41.13	14.91	33.52	39.62	14.89	42.79

I have adopted a plan for stating analyses of molasses by which each analysis can easily be compared with the others. Each percentage has been reduced to the basis of a molasses of a stated degree Brix or Baumé, 50° Brix for molasses from first sugars and 76° Brix for molasses from seconds. Fifty and seventy-six degrees Brix were selected as standards of comparison, since they represent approximately the average densities of the molasses from first and second sugars.

SUMMARY OF DATA COLLECTED AT MAGNOLIA STATION, SEASON OF 1886.

Governor Warmoth kindly gave me free access to the records of the sugar-house, from which the following data were obtained:

TABLE IX.—*Showing tons of cane worked, weight of juice extracted, percentage of extraction and the weight of first and second sugars and molasses per ton of cane for the four* periods into which the season was divided.*

	First period.	Second period.	Third period.	Fourth period.	Total.
Cane worked..........tons..	2,113.76	2,410.72	920.47	1,758.35	7,203.30
Juice extracted..........pounds..	3,225,385	3,848,740	1,430,881	2,757,870	11,262,876
Percentage of extraction..........	76.29	79.82	77.72	78.42	78.17
First sugar, per ton..........pounds..	116.40	124.56	111.57	124.43	120.47
Second sugar, per ton..........do....	36.27	43.75	34.16	44.59	40.53
Molasses, per ton..........do....	54.05	63.12	48.53	61.06	58.17

*The divisions of the seasons into periods were arbitrary, and were made when bad weather or other cause of delay permitted a thorough cleaning of the sugar-house.

Percentage of yield, sugars	8.05
Percentage of yield, first sugar	6.02
Percentage of yield, second sugar	2.03
Pounds first sugar (polarization 98.78) per ton of cane	20.47
Pounds second sugar (polarization 90.3) per ton of cane	40.53
Total sugar per ton of cane	161.00
Percentage of total sugar obtained in first product	74.82
Percentage of total sugar obtained in second product	25.18

Total number of acres of cane rolled	590.81
Total tons of cane rolled	7,203.3
Tons of cane per acre	12.19
Total pounds of sugar made	1,159,768.00
Pounds of sugar per acre	1,962.6
Total pounds molasses made (11.6 pounds per gallon)	418,563.00
Pounds molasses per acre	708.45
Pounds molasses per ton cane	58.17

TABLE X.—*Comparison of yield of sugar and molasses, seasons of* 1884–'85, 1885–'86, *and* 1886.

	1886.	1885–'86.	1884–'85.
Yield of first and second sugars ... per cent	8.05	7.43	6.87
Yield of all sugars ... do	....	....	*7.92
Yield of first and second sugars per ton of cane ... pounds	161.00	148.75	137.39
Yield of molasses per ton of cane ... do	58.17	....	58.25

*In 1884–'85 three sugars were made.

EXPERIMENTS IN FILTRATION.

When in New Orleans, in November, I received an invitation to visit the experiment station and witness a test of the Kleemann process for the filtration of the juice. This test on a small scale was very successful, and demonstrated clearly that all the juice could easily be filtered through presses.

This process was invented by Fritz Kleemann, of Schoeningen, Brunswick, Germany. It has been patented in all sugar-producing countries.

This process was first tested on a large scale with cane juice in Demerara at the following sugar-houses: Nonpareil, Lusignan, Enmore, and others. The Nonpareil house filtered the juice from 400 long tons of cane per day, through 8 presses of 18 chambers each. These tests were made in May, 1886, since when the process has been introduced into Porto Rico and Cuba.

The following is a description of the process as employed in cane sugar-houses, brown coal or lignite being the filtering medium. The raw juice is treated in the defecators or clarifiers with lime, as usual, except that a smaller quantity is required. The juice is then heated to a temperature between 160° and 180° F., and finely ground lignite or brown coal is added. The lignite or brown coal must be reduced to as fine a state of division as is practicable. The quantity of lignite to be added varies with the amount of sugar contained in the juice, and ranges from 5 to 10 per cent. of the weight of the sugar. The temperature of the mixture is maintained at from 150° to 170° F. fifteen or twenty minutes, and the juice is then pumped to the filter-presses. The filtered juice passes directly to the evaporating-pans, and the sirup, without further clarification or settling, can be immediately boiled in the vacuum-pan.

The juice left in the press cake in the filter-presses is obtained by displacement with cold water.

One 30-chamber Kroog press will filter 20,000 gallons of juice treated by the Kleemann process in twenty-four hours, ample time being allowed for displacement of the juice left in the press cake and for cleaning presses, changing cloths, &c. An ordinary laborer can manipulate the presses.

The amount of precipitate retained by a 30-chamber press will average 770 pounds. This precipitate contains 50 per cent. of its weight of juice, nearly all of which can be recovered by displacement.

The amount of press cake per ton of cane is approximately 46 pounds. Half of this contains an average of about 13 per cent. sucrose. Were this juice thrown away with the press cake it would result in a loss of $46 \times .50 \times .13 = 3$ pounds sugar per ton of cane worked.

Even at a low valuation per pound for sucrose, this loss, amounting to 30,000 pounds of sugar for a crop of 10,000 tons of cane, would be a large item. These figures are based on an extraction of 78 per cent. of juice from the cane.

TEST OF THE KLEEMANN PROCESS AT MAGNOLIA.

Early in December, at the request of Mr. D. D. Colcock, secretary of the Sugar Exchange, New Orleans, the Commissioner of Agriculture directed me to make a test of this process.

A sufficient quantity of lignite could not be procured, so, in accordance with the suggestions of Mr. Ernst Schulze, representing the owners of the process, finely ground charcoal was substituted. Experiment on a small scale showed that a slight modification of the process must be made where charcoal, bituminous coal, or certain other substitutes for lignite are employed.

The clarifiers at Magnolia are of the ordinary form and have a capacity of 533 gallons. The filter-presses were manufactured by the Hallesche Maschinenfabrik, of Halle, Germany. An ordinary piston-pump was used to force the juice through the presses. The juice was limed, as usual; *i. e.*, to neutrality. In order to determine the amount of charcoal required, experiments were made with varying quantities: (1) 10 per cent. of the weight of the sugar in the juice; (2) 7½ per cent.; (3) 5 per cent.

Any difficuly in filtration would indicate too little charcoal. As a result of this experiment it was found that the juice filtered equally well with 5 per cent. as with 10. Five per cent. is probably as little as could be successfully employed.

The juice was rapidly heated to the boiling-point, after liming, before the addition of the charcoal. The charcoal having been added to the mixture, was boiled and stirred thoroughly for ten or fifteen minutes and then forced through the presses.

One 21-chamber press filtered 2,670 gallons of juice in three hours, at the end of which time it was opened and the press cake removed. The chambers of these presses are not as large as those of the Kroog presses.

The filtered juice was perfectly clear and bright. It was immediately converted into sirup in the double effect. This sirup was as bright as the filtered juice. A portion of the sirup after standing several days in a glass vessel did not show the slightest sediment.

Analyses were made of the juice at frequent intervals during this work. A portion was taken from each sample for the determination of the albuminoids.

The proportion of albuminoids is expressed in the table, both as a percentage of the weight of the juice and in terms of the sucrose.

The sample No. 1 of the juice was taken from the first clarifier, and the first sample of clarified juice from the first portion of the filtered juice; consequently these samples represent the same juice

before and after clarification. The rest of the samples were taken at intervals from the presses and from every third clarifier of juice.

The average of these results will represent, as nearly as possible, the same juice before and after treatment.

TABLE XI.—*Showing analyses of juices before and after treatment by Kleemann process.*

Number.	A.					B.					
	Total solids. (Degree Brix.)	Sucrose.	Albuminoids.	Albuminoids per ct. sucrose.	Coefficient of purity.	Total solids (Degree Brix.)	Sucrose.	Albuminoids.	Albuminoids per ct. sucrose.	Coefficient of purity.	Charcoal per ct. sucrose.
	Per ct.	*Per ct.*	*Per ct.*			*Per ct.*	*Per ct.*	*Per ct.*			
1	16.01	14.89	.2500	1.68	93.00	15.31	14.89	.1563	1.05	97.25	10.0
2	16.19	13.54	.1625	1.20	83.64	14.29	12.27	.1438	1.17	85.86	10.0
3	16.06	13.53	.2188	1.62	84.24	16.66	14.53	.1313	.90	87.21	10.0
4	16.57	14.13	.1875	1.32	85.27	16.93	14.78	.1369	.93	87.30	10.0
5	15.96	13.41	....	......	84.02	16.16	13.60	....	......	84.16	7.5
6	16.09	13.61	.2188	1.60	84.59	16.76	14.60	.1625	1.10	87.11	7.5
7	15.47	13.04	.2625	2.01	84.29	16.81	14.62	.1625	1.10	86.97	7.5
8	15.97	13.34	.3062	2.29	83.53	17.56	14.90	.1618	1.08	84.85	7.5
9	14.51	11.81	.2938	2.48	81.39	17.01	14.43	.1338	1.27	84.83	7.5
10	15.27	12.43	.2563	2.06	81.40	17.47	14.75	.1875	1.27	84.43	7.5
11	15.21	12.82	....	......	84.28	17.44	14.65	....	......	84.00	7.5
12	15.70	13.17	.2375	1.80	83.88	17.30	14.76	.1762	1.19	85.32	5.0
Means	15.75	13.31	.2394	1.81	84.46	16.47	14.40	.1552	1.11	86.60	......

Average increase in coefficient of purity = 2.14.

In the preceding table, column A represents raw juices; column B, juices treated by Kleemann's process. Referring to table, we find the average increase in the coefficient of purity by the ordinary process to be 1.24. Table XI shows an increase of 2.14 by the Kleemann process. This large increase in the purity of the juice would give a decided increase in the yield of sugars.

THE ALBUMINOIDS.

The reduction in the percentage of albuminoids was not as large as by the ordinary process. By the Kleemann process an average of 35.17 per cent. of the albuminoids were removed; by the ordinary process the reduction was nearly 45 per cent. I do not know to what extent this difference in the albuminoids would affect the working of the sirup. The sugar-maker reported that the sirup made by the Kleemann process in this test worked as easily as by the ordinary.

ADVANTAGES OF THE KLEEMANN OVER THE ORDINARY PROCESS.

The increased coefficient of purity is not the only advantage this process has over the ordinary. There is an increase of sugar from the rapidity of working both juice and sirup. The quantity of sugar lost in the scums is reduced to a minimum. The expense for labor is less and the value of the press cake is greater, since it is in a better condition mechanically for use as a fertilizer.

This process certainly merits a thorough test by our sugar planters. Lignite of a good quality is abundant near the sugar area of Louisiana and can be obtained at a small cost.

CONCLUSION.

The results of this season's work at Magnolia have been very satisfactory. The yield of sugar per ton was the largest in the history of the plantation. The yield per acre was exceedingly small.

The results of the work of the sugar-house were very encouraging, and were such as to warrant a large expenditure for improvements in the plantation.

ANALYSIS OF SUGAR BEETS.

A large number of samples of sugar beets have been received from various parts of the country grown from seed sent out by the Department. The great variation in the content of sucrose in these samples shows the wonderful effect of soil, climate, and method of cultivation in the quantity of sugar which the beet contains.

From the appearance of the samples received it was evident that the greater number of those who had grown the beets were ignorant of the principles of agriculture on which the growth of a beet rich in sugar depends. The object in view seems to have been to produce a large beet, and many of the samples received were of a size far above that which indicates the production of large quantities of sugar.

To secure the best results the number of beets grown on each square yard should not be less than seven or eight. By judicious crowding the overgrowth of the beet is prevented, and the sugar is stored in the tuber instead of being used up in the life processes of the plant.

The beets sent by Joseph M. Hart, of Oswego, N. Y., have the appearance of having been grown in accordance with the above principles, and they afforded the only sample which reached the standard of a profitable sugar-making plant.

The low percentage of sucrose in the samples sent from the Middle and Southern States shows the folly of trying to grow the sugar beet in any parts of our country except those pointed out in Bulletin No. 5 of this division, viz, the Pacific slope and along our Northern borders. Following are the descriptions of the samples analyzed and a table of the results obtained:

DESCRIPTION OF SAMPLES.

	Serial No.
Sugar beet from K. P. Flinn, Woodville, Miss	4486
Sugar beet from M. S. Douglas, Fort Smith, Ark	4488
Sugar beet grown on stiff clay soil, from J. T. Henderson, Palmetto, Ga	4490
Sugar beet grown on red clay soil, weight 841 grams, from Mrs. T. F. Astin, Palmetto, Ga	4491
Sugar beet grown on stiff red soil, weight 472 grams, from J. M. Terry, Palmetto, Ga	4492
Sugar beet grown on clay soil, weight 973 grams, from J. H. Watkins, Palmetto, Ga	4493
Sugar beet grown on clay soil, weight 972 grams, from J. H. Watkins, Palmetto, Ga	4494
Sugar beet grown on clay soil, weight 648 grams, from J. H. Watkins, Palmetto, Ga	4495
Sugar beet grown on sandy loam, weight 872 grams, from Thomas Varnes, Palmetto, Ga	4496
2 sugar beets grown on fine loamy clay, weight 688 grams, from Mr. Milles, Palmetto, Ga	4497
White sugar beet from William Cleveland, Thornton, Tex	4571
White sugar beet from William Cleveland, Thornton, Tex. (beet short and stumpy)	4572
Sugar beets, very large, short, from V. D. Hannah, Weiser, Ind	4645

	Serial No.
Small sugar beet from William Gill, West Point P. O., Dak	4655
2 sugar beets from William Sache, Plano, Tex	4678
White Imperial sugar beet from F. E. Hurd, West Haven, Mich	4679
2 sugar beets from E. B. Cochran, Parma, Mich	4687
White Imperial sugar beet from W. J. Sweet, Clay Brook, Tenn	4688
Sugar beet, large, from H. F. Harbaugh, Concord, Kans	4689
12 sugar beets, very fine and fresh, from James M. Hart, Oswego, N. Y	4690
2 large beets from F. C. Smith, Portland, Oreg., raised on Ladd's farm	4691
2 large beets from F. C. Smith, Portland, Oreg., raised on Ladd's farm	4692
Large beet from F. W. Smith, West Haven, Mich	4696
2 large beets from M. Nelson, Menomonee, Mich	4736
2 large beets from E. B. Cochran, Parma, Mich	4737
8 sugar beets from H. P. Simmons, Paterson, N. J	4739
3 sugar beets from J. Browen, Bismarck, Ohio	4776
Sugar beet from A. M. Smith, Climax, Morrow County, Ohio	4777
7 White Imperial sugar beets, grown by David Oldhaven, Paterson, N. J	4781

ANALYSIS OF SUGAR BEETS.

Serial number.	Per cent. water.	Per cent. sucrose.	Serial number.	Per cent. water.	Per cent. sucrose.
4486	86.65	6.11	4678	84.86	5.04
4488	89.10	4.80	4679	81.63	9.76
4490	86.36	9.07	4687	86.27	8.35
4491	86.95	7.03	4688	83.99	7.86
4492	83.91	10.35	4689	87.34	8.03
4493	88.34	5.92	4690	85.11	11.71
4494	89.07	6.54	4691	83.23	8.58
4495	88.14	5.35	4692	83.07	8.22
4496	87.83	6.75	4736	80.88	18.84
4497	85.62	7.51	4737	87.73	10.30
4571	86.71	11.41	4739	85.71	11.15
4572	85.53	9.11	4776	82.37	9.35
4645	86.11	3.73	4777	80.80	10.09
4655	80.26	10.74	4781	84.08	8.18

SOILS SUITABLE TO THE CULTURE OF CELERY.

The culture of celery in this country, especially in Michigan, has grown to be an industry of considerable importance. In the neighborhood of Kalamazoo in Michigan I found some of the finest celery gardens of the world. To determine the character of the soil in which this celery grows a carefully selected sample of it was obtained from Mr. Frank Little, of Kalamazoo.

ANALYSIS OF THE SOIL.

This soil gave, on analysis, the following results:

Substances.	Per cent.	Substances.	Per cent.
Moisture	7.105	Soluble silica	.175
Hydrated silica	1.885	Alumina	3.237
Ferric oxide	1.880	Lime	4.574
Phosphoric acid	.470	Soda	.463
Potash	.206	Sulphuric acid	.601
Chlorine	.091	Carbonic acid	.408
Volatile and organic matter	52.342	Nitrogen	2.660
Quartz sand	23.845		

The great percentage of nitrogen in this soil will be noticed, which leads me to the conclusion that soils containing a large quantity of organic matter are particularly adapted to the growth and culture of celery.

It seems appropriate, in this connection, to insert the following very interesting account of the culture of celery, by Mr. Frank Little, of Kalamazoo, Mich.:

CELERY CULTURE AT KALAMAZOO, MICH.

By Frank Little.

Kalamazoo Township, 6 miles square, is the county or shire town of Kalamazoo County. The city of Kalamazoo, 2½ miles square, is located in the geographical center of the township, which is also, approximately, the center of the county, and is situated on the line of the Michigan Central Railroad, running east and west, and the Grand Rapids and Indiana, and Lake Shore and Michigan Southern, running north and south, midway between Detroit and Chicago, and at the great bend of the Kalamazoo River.

The valley of the river at this point is fully 100 feet below the general level of the table-land above, and averages 2½ miles in width.

The city of Kalamazoo, which is in the valley of the river, is built upon a burr-oak plain, which is slightly elevated above the bottom or marsh land that skirts the stream and its tributaries, the Portage, Arcadia, and Axtell's Creek, which all empty in within the city limits. The soil is a dark sandy loam, resting upon a substratum of coarse gravel and sand, in which is found an inexhaustible supply of pure water at a depth varying from 6 to 25 feet.

The upland timber consists of the several varieties of oak, hickory, maple, linden, elm, and other varieties.

The celery gardens of Kalamazoo are located upon the bottom or marsh lands that skirt the river and its tributaries. It is estimated that there are in the city and township 3,000 acres of bottom-land, a large portion of which is adapted to the cultivation of celery. This marsh soil is of inky blackness, peaty; in some instances strongly impregnated with iron, and in others with marl or carbonate of lime.

The saturation is copious as a rule throughout the season, owing to porosity of soil, and the elevation being but slight above the river level.

In 1875, or thereabouts, a native Hollander by the name of Lendert De Bruyn, who had carried on a small upland garden and tried to raise a little celery, ditched and spaded a narrow strip a few feet wide and two or three rods long of marsh at the rear of his lot on South Burdick street, and set out a few plants of celery as an experiment. His success was so marked that the next spring three or four other Hollanders in like manner prepared a few rods of ground with like results.

Stimulated by the uniform success that had attended these efforts, and a market being opened abroad by some enterprising dealers, a large number of Hollanders soon embarked in the work. Large tracts of marsh-land were ditched, subdued, and planted out to celery up and down the valley. Marsh-lands advanced rapidly in value from a nominal average price of $30 per acre to three, four, and five hundred dollars per acre.

At the present time (July, 1885) the total area of celery lands under cultivation within the city limits and suburbs is estimated at 1,200 acres, furnishing employment in this special industry to upwards of 2,000 laborers, besides a great number of women and children.

Notwithstanding this remarkable expansion and wonderful success attending the growth of celery in Kalamazoo, notably so within the past five years, the possibilities of the future have only been half realized. While the annual acreage is rapidly increasing, stimulated by a brisk, profitable demand for shipment, large areas of land—probably 1,200 acres more, suitable for the cultivation of the plant—are still unoccupied.

It is no genteel, light, clean work or child's play to grow celery. The drainage and subjugation of the natural soil, fertilization, planting out, and subsequent cultivation and gathering the crop—almost entirely hand work from the commencement to the close—is laborious in the extreme.

At first narrow open ditches are dug at right angles to the stream or principal drain at intervals varying from ten to thirty rods, as the case may require. The intermediate spaces between the ditches is then thoroughly dug up by hand or by plowing in some instances, covering underneath the wild coarse grass, weeds, flags, and rushes, preparatory to setting the plants.

Horses shod with broad wooden shoes made of 2-inch plank are sometimes used in plowing drier portions; also, sometimes, where too wet and miry for a team, a capstan set on the upland, with a long cable attached to a plow, is used, and a wooden tramway is laid for a light car to take the plow and cable back to the starting point, and for the transportation of manure, boards, tools, plants, &c., onto the field; but this is not the common practice now, as the marshes are drier than formerly.

Most of the labor in the celery gardens is done by Hollanders—men, women, and children—who, in wooden shoes, bid defiance to malaria and diphtheria, and seem

to be perfectly at home as they dig in the mud and water and plod over the moist celery fields.

In winter, when the marshes are frozen, large quantities of straw and stable manure are drawn out to the celery fields for spring and summer use. Manure—which has appreciated in value largely within the city limits since the development of this enterprise—is an essential feature of success. It is used liberally at each successive planting to promote the growth of the crop; and it is found that artificial fertilization here cannot be profitably dispensed with.

Celery seed is quite small and slow to germinate. Some growers raise their own seed, but a large number purchase it each year at a reliable seed agency.

There are many varieties, with scarcely essential differences. The most popular-named varieties at Kalamazoo are the Golden Dwarf, White Plume, and White Walnut.

Seed is sown in March in hot-beds; later on, in shallow boxes, and a finely prepared seed-bed outdoors. The seed should be sown in straight rows, so that the young plants may be kept free from weeds. When about 2 inches high they should be thinned out and transplanted 2 inches apart, and when 4 inches high the tops should be cut off, which will cause them to grow stocky.

Thorough cultivation is implied where celery has been raised upon any given tract the previous year.

In planting out, well-manured, broad, shallow trenches about 7 inches deep, parallel to each other and 5 feet apart—in some instances these trenches are only 3½ and 4 feet apart—are usually prepared; and the young plants are set in the trench at intervals of 6 inches; the outer leaves cut off, and the soil pressed closely around the roots.

Early plants are set in May, as weather permits; second crop in June; and third and last planting, for winter use, last of August and first of September.

Onions, peas, and potatoes are extensively planted between the trenches of the first crop, to be harvested before the celery needs hilling.

In about six weeks from setting out the plants may be "handled," one man gathering the leaves together tightly, while another draws the earth from between the rows about the plants one-third their height. The process is repeated in dry weather every few days until ready for use. Care must be taken that dirt does not fall between the leaves in hilling, as rot may ensue.

The hilling of the first crop excavates a trench, along which the second "planting out" is set before the first is harvested.

The first crop is usually ready for market by the 10th of July, and all gathered by the 1st of August. The soil is then taken from the first row for hilling the second crop. If the season is favorable, a third crop is planted out the 1st of September upon the first line of trench.

Blanching in the field is done either by hilling up the plants with earth, as previously described, or by boards placed each side of the growing plants, and held together by iron hooks or clamps. Where boards are used there is less liability to rust, but the celery is said not to be equal in quality to that which is hilled with earth.

At maturity the celery is dug, trimmed, washed in sluices running through the fields, securely tied in bundles of twelve heads—boys and girls being usually employed in this work—and delivered promptly at the shipping agencies, fresh from the field every day, just prior to departure of express trains.

At the agencies the celery is immediately packed in thin wooden boxes of uniform size—ten bundles of twelve heads each—duly branded "Kalamazoo Celery," and sent at once to the express trains.

In the height of the season 40 tons have sometimes been shipped from Kalamazoo of celery thus packed in a day.

It is important that celery reaches its destination in as fresh and crisp a state as possible. The utmost celerity is therefore requisite, from the moment the plants are lifted in the field, to hasten them to market in an attractive form and good condition. There are nearly thirty business firms engaged in the shipment of celery from Kalamazoo. These agencies buy the celery outright at a certain price per dozen heads, and it is then sold in quantities to fill orders or consigned for sale to commission dealers.

As the season advances and freezing weather sets in all the plants that remain in the gardens are lifted from their original bed and stored carefully away in winter cellars, or "coops." These winter repositories are built to exclude the frost, and have facilities for lighting and for heating in extreme cold weather. They are built usually 24 feet wide, and are 100, 200, and 300 feet long, as the case requires.

In constructing these "coops," which are built on dry land near the gardens, the earth is excavated about 2 feet below the natural surface for the entire area to be inclosed. The sides are boarded up above the natural surface 2 feet to the eaves,

making side walls 4 feet high inside. A ridge-pole, 6 feet high, is duly supported through the center, and 14 ft. boards are used for roofing, occasional openings being made in the roof for windows and ventilation. The outside is well banked up with earth to the eaves, and the roof covered with straw and manure to exclude the frost.

In housing the celery for winter, beginning at the back end of the "coop," the plants which are green and small as they are selected from the field are first packed away at the farther end, standing closely and upon their roots, slightly sprinkled with earth, and moistened, to keep them growing. To prevent heating, the plants, as they are stowed away, are divided into narrow sections by boards set edgewise. Green and immature plants are always placed at the back end, so as to be the last to come out in the early spring, when the season closes, while the large mature heads are saved to go in last near the door.

In this manner the "coop" is filled to the entrance with one or two hundred thousand dozens of plants, more or less, as the case may be.

The proper management of these winter cellars is a very important feature of the enterprise, and requires constant vigilance and excellent judgment to regulate the light, heat, ventilation, and steady successful bleaching of the plants.

Another method of winter storage is sometimes practiced by digging a trench 2 feet deep, 2 feet wide, and any desired length. The plants are then packed uprightly upon their roots in the trench as closely as they will stand, and covered with straw, earth, and manure to exclude frost.

While celery thus secured is said to be preferable, there are serious objections to the method in this latitude. For the plants, long excluded from the air, would smother and decay, there would be danger from frost, and they would be inaccessible many winters in case of protracted periods of very cold weather.

The winter demand for celery for shipment, especially during the holiday season, is constant and unabated; and the "coop" system enables the grower to obtain access to his stock every day, even in the coldest weather, and note its condition and prepare it for market, until the crop is exhausted.

Kalamazoo celery is now shipped to nearly every State in the Union. The regular season commences about the 1st of July, and, being prolonged by the practice of winter storage described, lasts until the succeeding March or April.

The annual product of celery at Kalamazoo is now estimated at upwards of 1,200,000 dozens, and valued at $250,000.

Kalamazoo celery takes high rank in the various markets where offered. It is remarkably uniform in size and quality; of luxuriant, rapid growth; crisp, aromatic, nutty flavor; and is generally sound and free from rust. Large, thrifty heads are generally more salable, but a medium size is to be preferred as being more tender and solid. As an esculent, it undoubtedly requires a cultivated taste to relish celery, but this taste is readily acquired; and as a condiment and appetizer, to say nothing of its valuable medicinal properties, celery stands unsurpassed.

The foregoing sketch of the rise and progress of celery culture in Kalamazoo but imperfectly delineates the development of an industry that has proved of great practical value not only to this locality, but the success and fame of the undertaking having gone abroad elsewhere in this State and in other States, the more extensive cultivation of celery has been stimulated in view of what has been accomplished here.

Land, much of it heretofore considered comparatively worthless, the original home of venomous reptiles, noxious weeds, swamp fever, and malaria, has been drained, brought under cultivation, converted into arable fields and luxuriant celery gardens.

While some of the drier portions of the Kalamazoo marshes were available for pasturage and meadows in dry seasons, yielding a coarse marsh grass of inferior quality, many large tracts that have been reclaimed were but a few years since wet and miry, almost impassable for either men or animals; and the idea of converting these lands to any practical use in the direction indicated would a few years since have been deemed visionary and absurd in the highest degree.

COMPOSITION OF WATER AND MUSK MELONS.

Many inquiries having been received at this office concerning the possibility of making sugar from water-melons, I was led to undertake an investigation of the content of crystallizable sugar in this fruit. At the same time a study was made of the other important constituents. The analytical processes employed were those usually

used in such estimations and it is not necessary to repeat a description of them here. The melons were bought in the open market and of several different varieties. In the case of water-melons, separate investigations were made of both the meat and the rind, the separation being made as nearly as possible at the junction of the red and the white portions. The localities where the melons were grown are mentioned in the table, and also the varieties. The analyses clearly show that in no case could water-melons be used for the manufacture of crystallized sugar. The highest percentage of sucrose found in any case was 4.19. The mean for the whole number of analyses of sucrose was 1.92, and of glucose, or reducing sugar, 4.33 in the meat. In the rind the numbers were .34 and 2.47 respectively. A table of the analyses of musk melons is also given. For further information respecting the composition of water and musk melons the following tables may be consulted:

Analyses of musk-melons.

Serial number.	Variety.	Date.	Total weight of melon.	Weight of melon taken.	Weight of juice.	Juice.	Specific gravity of juice.	Temperature, C.	Sucrose in unfiltered juice.	Filtered juice.		In melon.		In juice.	
										Sucrose.	Glucose, Fehling's solution.	Total solids.	Ash.	Total solids.	Ash.
			Gms.	*Gms.*	*Gms.*	*Per ct.*		°	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1	Jenny Lind	Sept. 5	3,012	3,012	2,067	68.62	1.029	24	.99	.49	3.03	6.67	.500	5.48	.410
2	......do	Sept. 5	2,881	2,491	1,827	73.34	1.019	25	.72	.72	3.49	6.42	.388	5.33	382
3	......do	Sept. 7	4,590	4,182	3,284	78.52	1.019	20	.98	1.09	3.57	6.81	.485	5.42	.443
4	......do	Sept. 7	4,656	4,233	3,172	74.93	1.026	21	1.74	1.67	3.12	7.53	.533	6.79	.523
5	......do	Sept. 8	2,801	2,546	1,950	76.59	1.022	23	1.48	1.67	3.03	7.74	.648	6.11	.590
6	......do	Sept. 8	3,056	2,793	2,170	77.69	1.017	22	.76	.67	3.12	6.74	.363	5.13	.413
7	Nutmeg	Sept. 9	1,913	1,815	1,398	77.02	1.031	26	1.97	2.01	3.22	9.64	.754	7.85	.705
8	......do	Sept. 9	2,078	1,948	1,506	77.31	1.028	26	1.42	1.42	4.55	8.75	.589	7.38	.573
9	......do	Sept. 10	1,929	1,840	1,298	70.54	1.021	23	.89	.89	3.33	7 09	.489	5.74	.437
10	......do	Sept. 10	1,369	1,237	857	68.47	1.027	24	1.60	1.60	3.03	7.82	.482	7.32	.460
11	Hunter	Sep . 11	4,957	2,279	1,858	81.52	1.022	23	1.23	1.23	3.38	6.60	.550	5.36	.536
12	......do	Sep . 11	4,753	1,855	1,574	84.85	1.020	20	1.03	.95	2.94	6.34	543	4 44	.523
13	......do	Sep . 12	2,693	2,254	1,841	81.67	1.014	23	.45	.36	2.68	6.24	.545	4.12	.418
14	......do	Sep . 12	3,827	3,207	2,724	84.93	1.012	22	.29	.37	2.43	5.38	.444	3.77	.423
15	......do	Sept. 14	4,123	1,879	1,612	85.79	1.010	25	.08	.12	2.43	4.67	433	3.24	.396
16	......do	Sept. 14	3,244	1,540	1,410	91.55	1.013	25	18	.25	2.73	3.60	466	3.81	.524
17	......do	Sept. 15	2,123	1,705	1,399	82.05	1.013	25	.05	.09	3.01	4.68	.543	4.36	.484
18	......do	Sept. 15	2,697	2,312	2,054	88.84	1.008	25	.14	.08	1.81	3.65	513	2.70	432
19	......do	Sept. 16	4,063	2,165	1,749	80.78	1.020	23	.68	71	3.44	5.66	.537	5.03	478
20	......do	Sept. 16	3,210	1,610	1,281	79.56	1.014	23	.33	.30	2.63	4.26	.474	3.19	.467
21	......do	Sept. 17	4,597	2,305	1,935	83.94	1.030	21	1.76	1.77	3.18	6.33	691	6.47	.671
22	......do	Sept. 17	4,098	2,130	1,693	79.48	1.030	22	2.64	2.73	2.22	7 27	.789	7.25	708
23	......do	Sept. 18	3,982	1,198	1,759	90.29	1.020	21	.89	.89	3.01	5.62	.836	5.09	.689
24	......do	Sept. 18	2,993	1,594	1,350	84.69	1.020	22	.87	.87	2.32	6.34	.743	4.99	713
25	......do	Sept. 19	5,131	2,189	1,737	79.35	1.035	23	3.10	3.10	4.00	11.41	.808	8.55	.749
26	......do	Sept. 19	3,740	1,680	1,406	83.69	1.020	23	.62	.44	3.28	4.35	608	4.94	622

Analyses of water-melons.

Serial number.	Variety.	Part taken.	Date.	Where grown.	Total weight of melon.	Weight taken.	Weight of juice.	Juice, meat, and rind.	Specific gravity, juice.	Temperature, C.	Filtered juice.				Whole melon.		
											Sucrose (polariscope).	Glucose.	Total solids.	Ash.	Albuminoids.	Total solids.	Ash.
					Grams.	Grams.	Grams.	Per ct.		°	P. ct.	P. ct.	P. ct.	P. ct.	Per ct.	Per ct.	P. ct.
1	Gipsy	Meat	July 31	North Carolina	8,515	1,870	1,476	77.32	1.016		1.31	3.70	5.70	.251	.2063	5.06	.246
2	do	Rind	July 31	do		1,523	1,259	82.66	1.008		1.27		3.54	.317	.2500	6.04	.467
3	do	Meat	Aug. 1	do	6,630	1,755	1,440	82.28	1.015		1.35	3.42	2.01	.324	.1625	6.05	.300
4	do	Rind	Aug. 1	do		1,528	1,288	84.92	1.007		.39	3.92	3.11	.408	.1625	4.70	.552
5	do	Meat	Aug. 3	do	7,027	1,745	1,256	71.56	1.017			3.60	4.71	.150	.1375	5.58	.215
6	do	Rind	Aug. 3	do		1,501	1,125	74.95	1.010			2.35	2.33	.159	.1187	5.04	.302
7	Rattle-snake	Meat	Aug. 4	Georgia	8,060	1,860	1,490	80.10	1.015		1.05	3.92	4.37	.234	.1813	4.95	.270
8	do	Rind	Aug. 4	do		1,990	1,527	76.73	1.008		.50	2.22	2.73	.385	.2500	4.37	.397
9	Joe Johnson	Meat	Aug. 5	Maryland	7,647	1,701	1,337	78.60	1.018				5.37	.221	.2563	6.39	.236
10	do	Rind	Aug. 5	do		2,024	1,451	71.69	1.010				2.90	.316	.2750	5.01	.395
11	do	Meat	Aug. 6	Eastern Branch	7,575	2,053	1,579	76.91	1.017		1.07						
12	do	Rind	Aug. 6	do		1,551	1,294	83.43	1.006		.53						
13	Ice-rind	Meat	Aug. 7	Eastern Shore	9,526	2,502	2,159	86.29	1.027		2.83		7.72	.265		7.72	.321
14	do	Rind	Aug. 7	do		2,296	1,941	84.54	1.012		.40		3.92	.442		5.02	.459
15	do	Meat	Aug. 11	do	9,450	2,536	2,122	83.67	1.027	25.5	2.07		7.63	.282		7.63	.271
16	do	Rind	Aug. 11	do		2,197	1,817	82.70	1.015	26	.05		5.34	.494		5.34	.510
17	do	Meat	Aug. 11	Fort Ward	9,371	1,448	1,194	82.45	1.030	26.5	1.36	5.43	7.84	.282		8.50	.272
18	do	Rind	Aug. 11	do		2,797	2,315	82.77	1.016	27		3.84	4.18	.409		5.94	.449
19	do	Meat	Aug. 12	Anacostia	8,430	2,052	1,683	82.82	1.025	28	2.19	5.00	6.29	.201		9.35	.260
20	do	Rind	Aug. 12	do		2,217	1,864	66.79	1.010	28	.26	2.45	2.79	.402		4.58	.376
21	do	Meat	Aug. 13	Prince George County, Md	7,690	2,473	2,166	87.59	1.025	29	1.76	5.00				5.25	.182
22	do	Rind	Aug. 13	do		1,525	1,201	76.87	1.014	28	.22	2.84				4.52	.538
23	Gray Taylor	Meat	Aug. 14	West Shore, Va	8,674	2,245	1,868	83.21	1.031	27	2.79	5.32	7.16	.189		8.32	.235
24	do	Rind	Aug. 14	do		2,252	1,874	83.22	1.016	26	.41	3.68	3.94	.416		5.27	.411
25	Rough and Ready	Meat	Aug. 15	Norfolk	13,375	4,160	3,644	87.55	1.025	23.5	1.53	4.58	6.14	.232		6.15	.279
26	do	Rind	Aug. 15	do		2,265	1,851	81.72	1.010	23.5	.23	2.15	2.69	.339		3.88	.401
27	do	Meat	Aug. 17	do	12,641	4,012	3,403	84.65	1.022	23	1.37	4.24	5.07	.262		7.88	.306
28	do	Rind	Aug. 17	do		2,227	1,744	78.31	1.010	24	.16	1.88	4.40	.480		5.60	.485
29	do	Meat	Aug. 18	do	11,174	3,120	2,607	83.54	1.016	25.5	.95	3.84	4.03	.260		5.81	.258
30	do	Rind	Aug. 18	do		2,265	1,568	69.26	1.009	26		1.89	2.49	.431		5.24	.472
31	do	Meat	Aug. 19	do	11,996	2,905	2,517	84.65	1.028	26	2.55	4.62	7.81	.222		9.13	.274
32	do	Rind	Aug. 19	do		2,614	2,183	83.51	1.013	26	.81	2.05	3.00	.569		5.42	.563
33	Cuban Queen	Meat	Aug. 20	Benning's Bridge, D. C	13,241	3,521	3,076	87.36	1.029	27.5	2.17	4.16	7.35	.398		8.75	.293
34	do	Rind	Aug. 20	do		2,935	2,490	84.84	1.012	27	.39	2.40	3.07	.432		4.56	.445
35	do	Meat	Aug. 21	do	12,917	3,489	2,892	82.60	1.029	25.5	2.21	5.00	7.26	.285		5.80	.335
36	do	Rind	Aug. 21	do		2,232	2,134	95.60	1.012	27	.43	2.43	3.41	.530		4.65	.485
37	do	Meat	Aug. 22	do	11,839	2,337	2,066	88.15	1.027	28	1.61	4.95	6.37	.250		7.40	.300

38	......do................	Rind....	Aug. 22	......do....................	....	3,205	2,624	81.87	1.010	27.5	.39	2.35	3.05	.448	....	2.74	.308
39	......do................	Meat....	Aug. 24	District of Columbia........	14,056	2,870	2,450	85.36	1.022	28.5	1.93	4.09	5.53	.199	....	8.13	.292
40	......do................	Rind....	Aug. 24	......do....................	....	3,257	2,715	82.74	1.007	28	.34	1.85	1.78	.354	....	3.26	.244
41	Black Spanish	Meat....	Aug. 25	......do....................	11,105	2,642	2,351	88.98	1.029	29.5	1.34	6.58	......	......	....	8.05	.328
42	......do................	Rind....	Aug. 25	......do....................	....	2,374	1,954	82.30	1.014	29.5	.44	4.85	......	......	....	6.25	.368
43	......do................	Meat....	Aug. 26	......do....................	10,548	2,808	2,232	79.48	1.020	24	1.26	3.93	......	......	....	8.46	.301
44	......do................	Rind....	Aug. 26	......do....................	....	1,948	1,557	79.93	1.012	21	.17	1.63	2.94	.217	....	4.13	.594
45	......do................	Meat....	Aug. 28	......do....................	12,575	4,278	3,878	90.64	1.025	20	1.67	4.09	8.72	.559	....	8.21	.252
46	......do................	Rind....	Aug. 28	......do....................	....	2,318	1,955	84.34	1.016	21	.18	3.03	6.82	.239	....	5.16	.463
47	......do................	Meat....	Aug. 29	......do....................	10,375	2,574	2,331	90.55	1.028	22.5	2.43	4.42	8.04	.508	....	8.59	.250
48	......do................	Rind....	Aug. 29	......do....................	....	2,279	1,959	85.96	1.019	22.5	.58	2.35	5.09	.371	....	5.70	.663
49	Cuban Sweet..........	Meat....	Aug. 31	Anne Arundel County, Md..	11,062	2,478	2,187	88.34	1.033	24	1.97	3.45	6.34	.503	....	8.29	.268
50	......do................	Rind....	Aug. 31	......do....................	....	2,348	1,897	80.79	1.018	23.5	.37	3.03	3.84	.232	....	5.13	.445
51	......do................	Meat....	Sept. 1	......do....................	11,695	2,882	2,534	87.93	1.031	23	......	......	4.85	.539	....	7.17	.254
52	......do................	Rind....	Sept. 1	......do....................	....	2,642	2,163	81.88	1.017	23	......	......	2.92	.250	....	5.28	.660
53	......do................	Meat....	Sept. 2	......do....................	10,787	2,765	2,384	86.22	1.031	21.5	3.26	3.06	7.99	.549	....	8.54	......
54	......do................	Rind....	Sept. 2	......do....................	....	2,454	2,068	84.27	1.014	22	.29	2.37	3.58	......	....	4.70	......
55	......do................	Meat....	Sept. 4	......do....................	11,269	2,552	2,116	82.92	1.033	23	4.19	4.06	......	......	....	....	......
56	......do................	Rind....	Sept. 4	......do....................	....	2,796	2,333	79.86	1.016	24	.03	2.90	......	......	....	....	......
	Means.............	Meat....	....	....	....	....	....	....	....	......	1.92	4.33					
	Means.............	Rind....	....	....	....	....	....	....	....	......	.34	2.47					

ANALYSES OF APPLES.

By Edgar Richards.

During September to October, 1885, an investigation was undertaken by the force in this Division to study the changes undergone by apples in drying. Some 22 samples of apples bought in the local markets were analyzed, and the results will be found in the annexed table.

METHOD OF ANALYSIS.

From 5 to 10 apples were taken for analysis; the fruit was weighed, then pared in an apple-parer, and reweighed. The peeled apples were cored by the ordinary culinary instrument for that purpose, then sliced up, a weighed quantity taken for drying, and the remainder used for the analysis of the fresh fruit. The sliced fruit was thoroughly mixed, so as to obtain a good average sample.

The drying was conducted in the large steam-oven at a temperature of 60° to 70° C. for twenty-four hours, care being taken to have a good circulation of air passing over the wire-gauze trays in which the samples were kept, in order to conform as nearly as possible to the usual method pursued with commercial fruit-evaporators. By this treatment an average of 96.03 per cent. of the total moisture contained in the sample was driven off.

After drying the fruit was reweighed and placed in glass-stoppered bottles, to prevent the sample from absorbing moisture, as the dried fruit was found to be quite hygroscopic if exposed for any length of time to the atmosphere.

On the fresh sample the following determinations were made:

(1) Loss on drying to constant weight at 110° C.

(2) Sucrose by extraction.

(3) Glucose by extraction.

(4) Fiber.

(5) Total solids and ash.

(6) Albuminoids by drying at 110° C., but not to constant weight, and combustion with soda-lime.

(7) Malic acid with $\frac{N}{5}$ soda.

(8) Specific gravity of the entire apple.

There was much difficulty in obtaining a suitable solution for the determination of the sugars by polarization or with Fehling's solution, as digestion of the sample with water in a closed bottle was found to dissolve the pectin, which rendered filtration, either under pressure or through paper, almost impossible. Glass wool, asbestus, linen, and charcoal were also tried, but unsuccessfully. The following method was finally adopted:

A weighed quantity of the sliced apples was digested for an hour in stoppered bottles, cooled, and the bottles then filled to the mark, 250 cubic centimeters; 20 cubic centimeters of the somewhat gummy solution was taken with a pipette and diluted to 100 cubic centimeters, and with this latter solution the determinations were made with Fehling's solution as usual.

The use of the polariscope was given up, as it was found extremely difficult to obtain a clarified solution, and when obtained the malic acid contained in the apples introduced a cause of error into the

analysis, as, according to Allen, it exerts when in dilute solutions a lævo-rotatory power.

Different results were obtained with the same lot of apples when worked on consecutive days, though the analysis done on the same days agree as fairly well as might be expected from the variation of the samples.

Inquiries were made of four fruit-evaporator manufacturing companies in regard to the method of procedure with their machines, and the following is a summary of the answers received from them:

What varieties of apples are used?

(1) All kinds. Acid apples best. A farmer's orchard of many varieties—acid or sweet, summer, fall, or winter apples—if evaporated as they come in season, and previous to packing for market are mixed, make a prime article.

(2) Nice white-flesh apples are the best.

(3) The better varieties make the better product.

(4) For evaporating, the Maiden's Blush, Smith Cider, Rome Beauty, Ben Davis, Baldwin, and Northern Spy are recommended.

How are apples prepared for the evaporator?

(1) Almost entirely by machines. (These machines will pare, core, and slice the apples in one operation, and in the catalogues sent by the companies several varieties are illustrated.) The fruit is pared, cored, and sliced at one operation, and done very expeditiously and cheaply. The apple is thus divided into uniform pieces, or rings, dries uniformly, and the trade in evaporated apples is almost exclusively in this kind.

(2) Either by machine or hand. Machine pared are the best, as the machine will slice the apple all the same thickness.

(3) The apples are prepared with a machine; pared, cored, and sliced into rings in one operation; then the rings are cut through with a knife and spread on a tray. When they come from the parer and before they are cut apart, they drop into a solution of salt and water, say, 1 pint of salt to 10 gallons of water. This cuts the gum on them and cleans them, and also prevents fermentation, and aids the bleaching also.

(4) The best machines are made with adjustable knives, and pains should be taken to adjust them so that they will not slice or ring the fruit too thick. Trim all bruises or specks; bleach as quickly as possible after they are prepared, and get into drier as quickly as possible. If not convenient to bleach as fast as prepared, fruit will keep brighter by throwing it into a tub of salt water until ready to bleach. (The bleaching is done either in a wooden box or in a special machine for the purpose; the object being to subject the fruit to the action of sulphur fumes; care being taken that this action is not too prolonged.) Evaporated fruits, especially apples and peaches, command a better price in the market when bleached, and it is conceded by all that the bleaching process not only improves the fruit in appearance, but in flavor and quality. The bleaching process consists in subjecting the fruits to a bath of sulphur fumes before evaporating. Fruit, especially apples, when cut and exposed to the air, becomes discolored or oxidized; the object of bleaching is simply to bring back the natural color. The sooner this is done after the fruit is cut the better; in fact, if we could put the fruit in the evaporator as soon as cut it would not be necessary to bleach it. The process not only brings back the natural color to the fruit, but also fixes the flavor. There is danger of overbleaching, in which event the smell and taste of sulphur can

be detected readily. Care must be exercised as to the quantity of sulphur used and the time the fruit remains in the bath.

What is the temperature at which they are dried?

(1) Averages between 180° and 250° F. Either extreme will do about the same class of work. The higher temperature evaporates very much faster.

(2) At about 180° F.

(3) 95° to 110° F.

(4) The temperature of about 200° F. will be sufficient amount of heat. Fresh fruit will stand 250° F. without burning or scorching.

How long do they remain in the evaporator before they are dried?

(1) At 180° F., about 3 to 5 hours. At 250° F., about 2 to 3 hours. This supposes the evaporator to be full of fruit and working full capacity. In experimental work, with but little fruit and moisture in machine, in absence of full charges of fruit the slices will dry in 30 to 60 minutes, but this would not be the case in practice when working for profit or on a business basis.

(2) This depends upon the kind of fruit that is used; some apples are more susceptible to evaporation than others. The average time would be 3 hours.

(3) They remain in the trays in the evaporators about 2 to 2½ hours.

How much weight do the apples lose in drying?

(1) Varieties differ considerably. Summer and early fall apples ordinarily yield in evaporated product 4 to 5 pounds. An average for winter apples would be 5 to 6 pounds. Some varieties of winter apples will yield 7 pounds, a few varieties, among them the russet, as much as 8 pounds. In this connection the degree of dryness enters as an important factor. Briefly stated, a fair average winter apple, economically trimmed, *i. e.*, pared, cored, and sliced, will yield 6½ pounds of evaporated fruit dry enough to pack and keep with safety for years. Many packers sprinkle their fruit with water before packing and considerably increase the weight. This practice is not commendable. The following experiments have been made:

Data obtained on one half bushel medium-sized peaches evaporated.

	Pounds.
Weight of one-half a bushel peaches	22½
Weight of pared fruit	19
Weight of seeds and pairings	3½

Evaporated product of above.

	Pounds.
Pared fruit	3⅜
Seeds and parings	1½

Data on one half bushel medium-sized fall apples.

	Pounds.
Weight of one-half bushel apples	19½
Weight of pared, cored, and sliced fruit	13¼
Weight of cores, parings, and trimmings	6

Evaporated product of above.

	Pounds.
Pared fruit	2½
Cores, parings, and trimmings	1¼

Data on one fourth bushel of apples, small, pared, and quartered.

	Pounds.
Weight of 1 peck	11½
Weight of evaporated fruit	1½
Weight of evaporated trimmings	½

(2) One bushel of apples will make from 6 to 7 pounds evaporated apples. The average is about 6 pounds to the bushel.

(3) Green apples weigh from 56 to 60 pounds, and the evaporated product about 6 pounds when done. The loss in actual weight would be about 50 pounds. They would weigh, after being peeled, sliced, and cored, about 35 pounds to the bushel, losing in the evaporation about 29 to 30 pounds; this is all water. By this process we save the saccharine qualities of the fruit.

(4) The time required to evaporate the different kinds of apples varies. In the following table each variety of apples was kept separate, and the result is as near an average as can be obtained on a large quantity evaporated. The difference in weight of any one variety is owing largely to the difference in the state of maturity. We also give the average time required to evaporate.

Varieties.	Weight per bushel of dried fruit.	Hours required to evaporate.
	Pounds.	
Roxbury russet	8½ to 9	2.30
Spitzenburg	6½ to 7	3.00
Greening	5½ to 6½	3.00
Baldwin	6 to 7	3.15
King	5⅓ to 6	4.00
Fall pippin	5½ to 6	3.00
Sweet	5½ to 6	2.45
Twenty-ounce	4 to 5½	3.00
Gilliflower	4 to 5	2.45
Holland pippin	4 to 5½	3.00
Seek no further	4 to 5	3.00
Belle flower	5 to 6	3.15
Average	5⅓	3.25

It will be seen from the above extracts that the actual methods adopted by the different companies do not differ very much, being more or less modified to suit the requirements of their own machines.

In drying the apples in the laboratory no attempt has been made to bleach, as we are not making any commercial article, but wish to conform as nearly as possible with the general practice in regard to temperature used in drying, &c.

Analysis of cored and peeled apples.

GENERAL DATA.

Number.	Variety.	Date.	Number of apples taken.	Specific gravity, whole apple.	Weight in grams. Whole apples.	Peeled apples.	Cored apples.	Peels by difference.	Cores.	Taken for drying.	Dried apples.	Loss in weight by drying.	Moisture
													P. ct.
3870	Smokehouse	Sept. 22	12	.8832	1,629	1,332	1,107	297	220	532	83	449	84.40
3871	Smokehouse	23	10	.8684	1,486	1,270	1,028	216	240	501	115	386	77.05
3872	New York pippins	24	11	.7838	2,095	1,845	1,708	250	116	802	110	692	86.29
3873	New York pippins, same lot	25	10	.7838*	1,842	1,590	1,471	252	109	749	190	559	74.63
3874	Smokehouse	26	10	.8678	1,464	1,244	1,150	208	83	553	147	406	73.42
3875	Fall pippins	28	5	.8383	1,289	1,122	1,059	157	57	528	86	442	84.02
3876	Fall pippins, same lot	29	5	.8225	1,447	1,264	1,189	174	67	564	86	478	84.75
3877	Smokehouse	30	5	.8636	768	(†)	573	‡195	......	171	26	145	84.80
3878	Smokehouse, same lot	Oct. 1	4	.8723	548	467	423	80	39	204	32	172	84.31
3879	Maiden's blush	2	5	.7789	609	(†)	460	‡149	......	225	35	190	84.45
3880	Northern spy	3	10	.8346	1,910	1,631	1,524	267	101	730	112	618	84.66
3881	Ben Davis	5	10	.8118	1,466	1,266	1,161	200	94	560	83	477	85.18
3882	King	7	10	.8302	1,363	1,163	1,063	200	100	537	84	453	84.36
3883	Smith's cider	8	10	.7919	1,301	1,108	1,004	186	96	493	75	418	84.76
3884	Rambo	9	10	.8461	1,221	1,049	960	166	85	458	75	383	83.62
3885	Blush pippins	10	5	.7649	1,022	877	826	160	47	412	60	352	85.44
3886	Paradise sweet	12	10	.7915	1,416	1,260	1,166	208	92	588	101	487	82.82
3887	English redstreak	15	10	.8260	1,698	1,430	1,334	276	196	638	109	529	82.92
3888	Winesap	17	10	......	954	732	671	172	111	341	64	277	81.23
3889	Nonesuch	19	10	.8295	986	816	721	170	95	350	57	293	83.71
3890	Golden pippins	20	10	.8164	2,004	1,703	1,584	301	119	725	125	600	82.76
3891	Lobster white	21	10	.8084	914	727	615	187	112	314	44	270	85.39
3892	Virginia crab-apple	22	20	.9197	943	770	605	173	165	287	47	240	83.62
	Average	......	....	.8309	......	......	......	......	......	......	......	......	83.00

ORIGINAL SAMPLE.

Number.	Variety.	Date.	Number of apples taken.	Moisture at 110° C.	Total solids.	Ash.	Albuminoids.	Sucrose.	Glucose.	Malic acid.	Crude fiber.
				P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
3870	Smokehouse	Sept. 22	12	86.47	13.53	.298	.112	(§)	(§)	.640	.89
3871	Smokehouse	23	10	86.07	13.93	.284	.094	(§)	(§)	......	......
3872	New York pippin	24	11	87.83	12.17	.302	.131	(§)	(§)	.480	1.04
3873	New York pippin, same lot	25	10	86.14	13.86	.324	.094	(§)	(§)	*.480	1.09
3874	Smokehouse	26	10	85.60	14.40	.404	.088	(§)	(§)	.670	.89
3875	Fall pippin	28	5	86.18	13.82	.335	.094	1.78	8.62	.640	.86
3876	Fall pippin, same lot	29	5	87.19	12.81	.354	.131	2.60	7.40	.790	.87
3877	Smokehouse	30	5	86.87	13.13	.281	.131	.84	8.62	.590	1.09
3878	Smokehouse, same lot	Oct. 1	4	87.74	12.26	.262	......	.40	10.30	.640	1.08
3879	Maiden's blush	2	5	88.00	12.00	.245	.088	.94	8.80	1.050	.86
3880	Northern spy	3	10	86.57	13.43	.291	.069	.15	10.25	.540	.87
3881	Ben Davis	5	10	85.86	14.14	.283	......	2.50	8.00	.540	.94
3882	King	7	10	85.89	14.11	.231	.138	.95	7.55	.430	.81
3883	Smith's cider	8	10	86.51	13.49	.275	.088	.64	8.32	.620	.84
3884	Rambo	9	10	84.60	15.40	.295	.088	1.98	9.67	.400	.75
3885	Blush pippin	10	5	86.83	13.17	.353	.100	.22	8.43	1.180	.84
3886	Paradise sweet	12	10	85.32	14.68	.235	.081	2.94	7.52	.190	.96
3887	English redstreak	15	10	86.57	13.43	.325	.131	2.29	8.63	.540	1.1[illegible]
3888	Winesap	17	10	83.45	16.55	.279	.131	2.38	9.40	.670	1.0[illegible]
3889	None such	19	10	85.42	14.58	.228	.088	1.16	10.80	......	.9[illegible]
3890	Golden pippin	20	10	87.05	12.95	.249	.175	2.23	7.69	.830	1.2[illegible]
3891	Lobster white	21	10	89.40	10.60	.255	.150	2.81	6.89	.390	.7[illegible]
3892	Virginia crabapple	22	20	86.35	13.65	.240	.131	2.53	10.24	.560	1.2[illegible]
	Average	......	....	86.43	13.65	.288	.111	1.53	8.73	.619	.9[illegible]

Analysis of cored and peeled apples—Continued.

DRIED SAMPLE.

Number.	Variety.	Date.	Number of apples taken.	Moisture.	Total solids.	Ash.	Albuminoids.	Sucrose.	Glucose.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
3870	Smokehouse	Sept. 22	12	18.53	81.47	1.768	.838	(§)	(§)
3871	Smokehouse	23	10	....	....	....	.419	(§)	(§)
3872	New York pippins	24	11	12.43	87.57	1.697	.663	(§)	(§)
3873	New York pippins, same lot	25	10	....	....	....	.594	(§)	(§)
3874	Smokehouse	26	10	....	....	....	.313	(§)	(§)
3875	Fall pippins	28	5	19.31	80.69	1.901	.838	7.30	44.40
3876	Fall pippins, same lot	29	5	15.22	84.78	1.858	.875	10.85	54.05
3877	Smokehouse	30	5	13.73	86.27	2.066	1.280	3.08	66.13
3878	Smokehouse, same lot	Oct. 1	4	11.18	88.82	1.709	1.500	Lost.	58.60
3879	Maiden's blush	2	5	14.18	85.82	1.275	.525	3.30	59.10
3880	Northern spy	3	10	13.14	86.86	1.554	.419	14.77	54.06
3881	Ben Davis	5	10	7.30	92.70	1.518	.700	8.02	54.16
3882	King	7	10	10.49	89.51	1.508	.944	14.12	51.07
3883	Smith's cider	8	10	16.11	83.89	1.587	.525	9.77	55.67
3884	Rambo	9	10	14.54	85.46	1.534	.594	4.47	58.82
3885	Blush pippin	10	5	13.25	86.75	1.795	.700	4.41	62.34
3886	Paradise sweet	12	10	16.63	83.37	1.404	.488	12.80	48.54
3887	English redstreak	15	10	17.45	82.55	1.755	.663	7.67	52.35
3888	Winesap	17	10	14.42	85.58	1.305	.806	12.41	47.61
3889	Nonesuch	19	10	16.48	83.52	1.571	1.050	11.88	44.92
3890	Golden pippin	20	10	8.13	91.87	1.603	.525	....	....
3891	Lobste white	21	10	15.44	84.56	1.350	.875	....	....
3892	Virginia crabapple	22	20	9.96	90.04	1.266	1.119	....	....
	Average	....	....	13.90	86.04	1.601	.750	8.91	54.12

*Same sample. †Not taken. ‡And cores. §Not enough filtered solution for estimation.

The average composition of the original and dried samples of the cored and peeled apples is as follows:

Constituents.	Original.	Dried.
Moisture .... Per cent.	86.43	13.90
Albuminoids .... Per cent.	.111	7.50
Sucrose .... Per cent.	1.53	8.91
Glucose .... Per cent.	8.73	54.12

Calculating these results to moisture-free substance we obtain:

Constituents.	Original.	Dried.
Albuminoids .... Per cent.	.82	.87
Sucrose .... Per cent.	11.28	10.35
Glucose .... Per cent.	64.33	62.85

This comparison shows that there is practically no change undergone by the fruit in drying beyond expelling the moisture.

EXAMINATION OF MEATS.

By A. E. Knorr.

The samples of different kinds of meats were obtained in open market, and therefore represent a fair average of the home consumption of this most important article of food.

In order to prepare the meat for analysis the fat, bone, gristle, and

flesh were carefully separated and the weight of each ascertained, in order to show the relative proportions of each of these constituents in the different kinds of meat and different portions from the same animal. The flesh was then put through a sausage-grinder, care being taken to get as little of the tendons and fasciæ in as possible.

Of the meat thus prepared a sample was taken for analysis, which was made in the following way:

Total solids.—Five grams were weighed out in a light glass capsule and dried over night at a temperature of from 100° to 105° C. The difference between the original weight taken and the total solids obtained represents the total water.

Fat.—The dry sample of meat was then extracted in a Soxhlet apparatus over a weighed flask with ether.

Alcohol extract.—The alcohol extract was obtained from the residue of the fat determination in the same manner. This extract contains the non-albuminoid nitrogen, as kreatin, kreatinin, sarrkin, xanthan, inocenic acid, and urea; acids of the fatty series, as lactic, butyric, acetic, and formic, and glycogen and inosit. The quantity of most of these constituents is extremely minute, and some of them, like glycogen, are normally found only in certain organs, as the liver, &c.

Nitrogen in extracted meat.—The extracted meat was then burnt with soda-lime, and the nitrogen thus obtained represents all the albumen and the albuminoids from the sheaths and fibers of the muscle.

Total nitrogen.—A sample of .5 gram of the meat was also burnt, giving the total nitrogen, amide, and albuminoid.

Total ash.—Another sample of 5 grams was dried in a tared platinum dish and weighed, in order to check the first determination of total solids. It was then incinerated, the ash weighed, and the total phosphoric acid determined therein by the ordinary molybdate of ammonia method.

Glutin.—Another sample of 5 grams was crushed to a fine pulp in a porcelain mortar and repeatedly percolated with cold water on a tared filter. After complete exhaustion the filter was dried and the residue weighed as glutin. This represents the nitrogenous principle of the muscle fiber, and the sheaths of the same. The fiber of the muscles is soluble in dilute hydrochloric acid and in the digestive fluids of the alimentary canal, whereas the muscle fiber-sheaths are soluble in boiling water, yielding gelatine.

Soluble albumen.—The filtrate from the glutin was heated to boiling in order to precipitate the albumen, which was filtered through a tared filter, washed with hot water, dried, and weighed.

Extract.—The filtrate from the soluble albumen was evaporated to dryness and weighed. This extract, on the whole, would approximately represent the same principles as the alcohol extract.

Ash in extract.—This was determined in the usual manner by incinerating the extract, and finally a determination of the phosphoric acid in the extract was made.

These examinations were begun with the expectation of making a thorough study of American fresh, salt, and canned meats; but more important work compelled the abandonment of the plan, at least for the present.

The analyses, however, show some of the more important nutritive values of the ordinary meats exposed in our markets.

Table of meat analyses.

Sample.	Number.	Date.	Price per pound.	Number of pounds.	Total weight.	Weight of flesh.	Weight of fat.	Weight of bone.	Weight of gristle.	Total solids.	Ash.	P_2O_5.	Glutin.	Soluble albumen.	Water extract.	In water extract.		Fat.	Alcohol extract.	In residue from alcoholic ext.		Total nitrogen.	Total albumen.
																Ash.	P_2O_5.			Nit.	Alb.		
			Cents		Gms.	Gms.	Gms.	Gms.	Gms.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	Per ct.	Per ct.	P. ct.	P. ct.
Brisket roast	2916	Nov. 13	10	5¼	2,422	815	856	426	308	28.82	1.10	.40	15.64	1.53	3.10	1.16	.32	8.15	2.70	2.84	17.75	3.24	20.25
						*33.05	*35.34	*17.59	*16.72	28.92	1.14	.44	11.80	2.26	3.20	1.07	.31	9.16	2.75	2.57	16.06	3.24	20.25
Rump roast	2917	14	13	5½	2,384	1,634	120	191	405	24.99	1.21	.52	11.93	2.23	3.75	1.23	.37	2.17	3.64	3.08	19.25	3.36	21.00
						*68.54	*5.03	*8.01	*17.00	25.01	1.22	.27	13.96	2.32	3.81	1.22	.41	1.80	3.61	3.08	19.25	3.36	21.00
Pork chops	2918	17	13	4¼	2,006	842	515	552	78	33.48	1.32	.51	13.99	2.52	3.54	1.15	.48	12.35	3.02	3.08	19.25	3.24	20.25
						*41.97	*25.62	*27.52	*3.89	33.08	1.26	.55	15.32	2.47	3.55	1.15	.49	11.55	3.10	3.07	19.18	3.24	20.25
Tenderloin roast	2919	18	18	4	1,764	751	459	386	156	27.38	1.24	.49	15.12	2.10	3.77	1.19	.55	6.23	3.27	2.80	17.50	3.24	20.25
						*42.57	*26.02	*21.88	*8.84	26.39	1.19	.52	17.12	2.53	3.75	1.05	.34	4.20	3.26	2.85	17.81	3.24	20.25
Rib roast	2920	19	13	5	2,289	1,323	560	128	258	27.07	1.12	.59	15.19	2.01	3.73	1.12	.34	5.16	3.09	2.97	18.56	3.42	21.37
						*57.80	*24.90	*5.59	*11.27	27.04	1.10	.59	......	2.28	3.61	1.05	.32	5.33	2.87	2.97	18.56	3.42	21.37
Rib roast	2921	20	13	5½	2,411	1,697	263	290	140	25.09	1.18	.61	14.37	1.68	3.44	1.20	.37	2.48	2.96	2.74	17.12	3.24	20.25
						*70.39	*10.09	*12.27	*5.81	25.06	1.34	......	15.22	1.70	3.21	1.09	.33	2.85	2.96	2.69	16.81	3.24	20.25
Round roast	2922	21	15	6	2,768	1,957	350	263	181	25.48	1.16	.52	14.94	......	4.50	1.08	.38	2.83	2.67	2.91	18.18	3.36	21.00
						*70.70	*12.65	*9.50	*6.53	25.40	1.13	.52	13.49	......	4.05	1.11	.37	3.08	2.16	2.94	18.37	3.30	20.62
Tender rib roast	2923	24	16	6	2,412	1,293	655	228	217	28.81	1.05	.46	13.93	1.90	3.50	.95	.31	7.96	2.27	2.58	16.12	3.24	20.25
						*53.61	*27.56	*9.45	*9.00	28.78	1.05	.44	14.67	2.01	3.43	.90	.33	8.50	2.31	2.58	16.12	3.24	20.25
First cut rib stew	2924	25	14	6	2,825	1,367	826	307	292	25.88	1.30	.32	13.05	1.79	3.18	.99	.31	5.06	2.91	2.63	16.43	3.42	21.37
						*48.39	*28.86	*10.87	*10.34	25.78	1.08	.44	......	1.56	3.16	1.03	.45	4.58	2.92	2.58	16.12	3.42	21.37
Round stew	2925	28	13	6	2,807	2,015	206	......	531	25.79	1.22	.50	11.42	2.89	3.89	1.20	.40	1.29	3.68	3.14	19.62	3.81	23.81
						*71.78	*7.34	......	*18.89	25.82	1.21	.52	11.90	3.00	4.15	1.25	.40	1.35	3.71	3.14	19.62	3.75	23.43
Veal cutlets	2926	Dec. 1	20	6¼	3,161	1,680	457	518	378	23.72	1.17	.50	10.82	2.94	3.01	.94	.32	.72	3.33	2.83	17.68	3.42	21.37
						*53.15	*14.46	*16.39	*11.96	23.82	1.15	.52	11.28	3.05	2.99	.98	.33	1.13	3.47	2.86	17.87	3.64	22.75
Means	......	......	......	......	......	....	......	......	......	26.89	1.18	.49	13.76	2.24	3.56	1.09	.38	4.93	3.03	2.86	17.88	3.37	21.04

* Percentage in original sample.

MISCELLANEOUS WORK OF THE DIVISION.

Among the large number of substances examined and analyzed for the information and benefit of the agricultural classes there are but few which are of such general interest as to make their publication and preservation in this place desirable.

Since the publication of our last report over one thousand samples have come into the hands of our chemists for examination, and have been reported on with undoubted advantage to the farming community; this, in a large number of cases, being of a negative sort, preventing many from indulging in schemes which possessed no basis in reason, information in regard to minerals, mineral springs, coal, waste products, &c.

In addition to this miscellaneous work, a systematic study of the methods of detecting food adulteration, conducted in the manner described under "Dairy Products" and "Condiments and Spices", is now making with baking-powders, teas and coffees, ciders, beers and native wines, flour and meal, &c.

These studies are not sufficiently completed to be described in the present report.

The work of the division is constantly increasing, and both the necessities of a large laboratory and the comfort of those engaged in other parts of the building require that a new building should be provided for the chemical work.

Respectfully,

H. W. WILEY,
Chemist.

Hon. NORMAN J. COLMAN,
Commissioner.

REPORT OF THE STATISTICIAN.

SIR: I have the honor to submit my eighteenth annual report as Statistician, the first reporting the operations of the Division of Statistics for 1865—the series running to 1878, inclusive, and from 1881 to the present time.

The past year has been one of progress in the direction of comprehensiveness and thoroughness in statistical work. The need of accuracy and reliability in original data is more and more accepted as a necessity, and the completeness in statistical exposition is more generally acknowledged. The overwhelming volume of transpiring facts, accumulating daily, and the haste and necessary superficiality of their treatment by the publicists of the time, suggest the desirability of closer analysis and more accurate deduction in statistical work. There is possibly an ampler opportunity and better facilities for progress in this direction, under official auspices, than under the limitation of personal effort and private means. An especial responsibility, therefore, attaches to Government statisticians, and requires at their hands the largest and best attainable results. They are, however, subject to the limitation, due to the imperfections, not to say abuses, which inhere more or less in all civil-service systems. There is probably a higher degree of impartiality in official statistical work than in private investigation, which is so apt to be undertaken for a specific object, to support some hypothesis for personal or corporate gain, or in attempted establishment of a foregone conclusion. It is true that official work may be tinged with partisanship or warped by personal prejudice, though the tendency of scientific co-ordination of living facts, which bear upon human destiny and progress, is towards the truth, in all its clearness and depth, unbiased by extraneous and comparatively unimportant considerations.

The agricultural statistics of this country represent an annually increasing volume of production and a constantly widening variety of product, rendering the collection of current data difficult and laborious. The difference in rapidity of settlement and agricultural development of the several States and Territories also complicates the question of comparative areas and products.

The corps of county reporters is larger than at any former time, including one chief correspondent and several assistants for each of 2,258 counties, comprising all but an insignificant portion of the productive territory of the United States. The State agents have also a separate staff of local assistants, making reports parallel with those of the correspondents reporting direct to the Department, and local investigations as required.

The work of Mr. Edmund J. Moffat has been continued at London, with the aid of consuls at continental commercial centers, with discretion, energy, and efficiency. Monthly reports have been made in season for publication simultaneously with domestic crop statistics,

showing the crop prospects, probable surplus or deficiency, of such European products as suffer competition from the surplus of the United States.

SPECULATION AND CROP REPORTING.

With increased public appreciation of the utilities of statistics, and resulting enlargement of statistical facilities, come organized efforts to turn to personal account the information, and practical benefits of statistical collection. This is natural and proper if legitimately done. A trade guild, a company, or an individual has a natural and moral right to obtain early, even exclusive, information, to use as buyers or sellers rather than for general or for public use, but not the right to distort, color, or falsify the apparent or obvious truth for purposes of deception, mystification, and robbery of producers or others. Yet such selfishness will be exhibited in the use of crop-reporting machinery, and attempts to mislead and plunder the public will follow, while greed of gain and crooked dealing have foothold in the marts of trade.

The false estimates of approaching harvests are put forth with more than the energy of conviction, which brooks no denial or question; and unfortunately they readily gain publicity through prominent daily and weekly journals. They serve their purpose like any stock-jobbing canard, and are apparently forgotten by the public. They may live through one season by persistent assertion, but never till the next. Careful and intelligent people are not deceived by them, but the great masses are not experts, and often accept a statement that is vigorously uttered, and are thus deceived. There is no necessity for such self-deception, as the official reports of this Department, and those of the State statistical organizations, and of newspapers and other crop-reporting agencies, that are honestly seeking accurate information, are sufficiently uniform, while unequal in facilities and accuracy of interpretation, to give substantially correct views. These several sources of information would be much more uniform if the returns were properly averaged with reference to quantity represented in each return. An average made from the number of returns, without regard to the great difference in the quantity of product represented by each, is worthless, and in extreme instances may be 50 per cent. out of they way; and yet most of the averages published are inaccurate and a misrepresentation of the reports of which they are a consolidation.

The efforts of speculators to profit by crop reports assume various phases. In some cases they claim to have superior or exclusive information by some prescience or system of crop researches of their own, and so large a philanthropy withal that they hasten to make it known with telegraphic celerity. In others they seek authoritative information in advance of its promulgation. Another class, with greater facility and at less expense, invent estimates, claiming them to be official and exclusive, for instant use at the exchange. Rarely they may be good guesses; generally they bear little resemblance to the results they assume to present in advance; always they are conscienceless falsehoods in their pretense of origin. Not unfrequently on the 9th of the month some one in speculative circles attempts to trade on data assumed to represent the tenor of the report of the Statistician of this Department on the 10th. Never have any such data been obtained from this office within the knowledge and belief

of the present incumbent. It would be quite as practicable to guess successfully the result as to obtain it of any subordinates of the office.

There is also a class of speculators whose estimates of crop conditions are supposed to coincide with their interests, who are constantly seeking to impress their views upon the Statistician, and sometimes upon the Commissioner. Some may be unconscious of the bias which self-interest inevitably gives their views, and sincere in their depreciation of the estimates which they deem so viciously destructive to the farmer's income (if they want high prices), or so inimical to the welfare of the great body of consumers (if they want prices low); but it exists, as is evident at the time, and proved triumphantly when the records of crop distribution show, as they usually do, that the estimates of the Department are very nearly correct.

WHAT DOES 100 MEAN?

Inquiry is often made, by persons who have given little attention to crop reporting, as to the basis or unit of percentage returns. It is simply the application of the decimal system used in the United States as the measure of money, and in France in the metric system, to the accurate expression of crop estimates. In comparisons of area with that of the previous crop, 100 represents the acreage of the previous year. In product, the present may be compared with that of the previous year, or with an average yield, 100 being the basis in each case. In reports of "condition" of growing crops, 100 is the standard of full condition, representing perfect healthfulness, exemption from injury from insects or drought or other cause, with average growth and development. Condition of a crop can never go above 100, except from one cause, unusual or extraordinary development and vigor of plant which more than counterbalances any deficiency in the stand or other loss.

As a rule, the existence of local drought, destruction by storm or floods, insect injuries and blights, one or more of those various causes of reduction of yield operates to reduce the average of condition in the latter part of the season. Some crops are more liable to injury than others. Cotton, for instance, in the most northern latitude of its production, as in this country, has many enemies. It is a plant that needs much sunshine and high temperature, with a moist but not saturated soil, and therefore an evenly-distributed rainfall. It is also liable to destruction by several distinct species of insects. Therefore the averages are quite sure to fall after the June and July investigation, as the results of fruiting are developed sometimes as low as 66 in October in the worst years. The average of ten years past is 80.

What does the condition 100 mean in bushels or bales? This is often the impatient question of one who wants a prediction of the harvest, who is determined to know what the fruit will be before the blossom has appeared. It is easy to say, for any region or State, what a full crop as represented by 100 should produce, as ascertained by records of past production compared with the harvest averages of each year. It is easy to calculate the present expectation from any reported average. But the crop does not remain stationary, causes of loss are developed from month to month, and the final result is below 100, perhaps much below; and instead of comparing the product with the latest average, inconsiderate persons often insist on comparing it with the record of an earlier month. There is no need of

this unfair comparison; it comes from haste and want of consideration. Experts in crop statistics find no difficulty in making accurate comparisons. Mr. Ellison, of Liverpool, the commercial authority as to the cotton movement, has said that he is always able to determine quite accurately the extent of the cotton crop from our record of averages of condition; and yet cotton is the most difficult of all the crops to forecast, because it is a plant that retains in cultivation something of its natural perennial character, and continues to grow, blossom, and fruit till it is destroyed by frost, the aggregate result thus depending on the length of the season.

We answer the inquiry as to what 100 means in reports of condition, that in a county where a full crop of corn is 30 bushels, 100 means a prospect for a crop of 30 bushels; 90, an expectation of 27 bushels; 70, of 21 bushels; and in similar proportion with other percentages. If the county is one in which 20 bushels is a full crop, 90 means a prospect of 18 bushels. There are districts where 40 bushels may be taken as a full crop; in such lands 75 would mean 30 bushels. In wheat there are regions where 8 bushels may be indicated by 100, and other districts where it may promise 20 bushels. In these instances 75 would mean 6 and 15 bushels, respectively.

The equivalent value of 100 in a general crop average must, therefore, be calculated with painstaking accuracy and thoroughness from the local equivalent values which are elements of this national average. Should the acreage of one year contain a larger proportion of poor lands than another, 100 would mean less in consequence. It seems almost trivial to dwell upon a point that a school-boy in primary mathematics should plainly see; yet there are persons who cannot apparently understand why 100 should not mean as many bushels for wheat as for corn, or why it should have a different measure in different States. Occasionally a newspaper writer, with only slightly bucolic leaning, meets with the same imaginary difficulty, and proceeds to criticise what he fails to understand through a fault all his own.

Some have suggested a report in bushels, tons, bales, &c. Aside from the incongruity of reporting results of the harvest, when only condition of an immature crop is intended, it would be impracticable. The direct estimates of yield per acre, even when made at the time of the harvest, are usually inaccurate, being almost invariably too high, whether from pride in local fertility or from undue prominence given to the areas of the best cultivators. There is less of inaccuracy, less of unconscious bias, in the percentage returns of condition on the basis of perfect healthfulness and medium growth. The experience of this office is opposed to the substitution of bushels, &c., for percentage of full condition in the reports of the status of growing crops.

THE OLD-FASHIONED PLAN.

The old method, the newspaper plan of crop-reporting in vogue so long and still practiced in some quarters, has little of system or science to recommend it; yet it assumes to have a standard of comparison which is an "average" crop. Really an average crop is a true average of the actual crops of a series of years. Ten years ought to suffice as a basis of average, though probably a truer average would require fifteen or twenty. In this Department the average of any ten years is found to be very close to that of any other similar

period. In wheat it varies little from 12 bushels per acre, usually a fraction above in any period taken. Corn varies little from 23 bushels. Yet there is a confusion of ideas of this term "average." Some, instead of reporting the average of all crops, good and bad, refer to an ideal standard of production; a full crop, represented by 100, as in our basis of condition. In the course of time averages may change with improved cultivation, but the constant enlargement of area, by extension of settlement, prevents much change in the United States.

Having decided on what is an average, the old-style reporter makes his returns. Instead of precision of expression, capable of exact mathematical rendering, he reports in language like this: Barely average; fairly good; moderate; middling; light; variable; very poor; indifferent; promising; much above average; very good; heavy crop; and every imaginable form of expression, utterly impossible of formulation in figures, because nine men out of ten might give a different percentage value to nearly all of them. If every reporter were infallible in judgment, his form of expression can never be interpreted by others, and therefore what is true in his judgment is false as rendered.

This is so notably the case that, unless the compiler makes a false pretense of an ability to interpret language that is inexpressible in figures, he contents himself with arrangement of returns in three classes: one an "average," one above it, and one below. All that such returns can show, therefore, is whether a larger number of persons report "above" than the number reporting below. Should 80 persons, for instance, report a prospect above average and 70 a lower condition, it would popularly be assumed that the crop was slightly above average. It might be, unless the 70 below average represented a larger area or rate of yield than the 80, in which case the returns would really indicate less than an average crop. As there is nothing to indicate how much above or below an average a return may be, it is impossible to know whether the 80 returns mean as much as the 70. So this form of return is nearly meaningless. It is not sufficiently definite; it does not express such discriminative judgment as is quite possible to render. Some reporters, aware of this absurdity, estimate in definite proportions: half, two-thirds, or three-fourths of an average crop. This is correct in principle, but not sufficiently close; it is only a little less absurd; for any man of good judgment ought to be able to estimate within 5 per cent. of the truth, and to discriminate more accurately than by jumps of 15 to 25 per cent. in an estimate.

Such indefiniteness of expression results from these clumsy methods, which foster carelessness and inaccuracy in crop estimates. This loose and worthless method of reporting has had its day, and should be discarded.

It can be demonstrated, from experience with statistical returns, even when they are mathematically and accurately rendered and consolidated, that there is either tendency to make a full crop the "average" crop, or else to make the comparison with an "average" standard somewhat too low. There is a practice out West of comparing with a five years' average, *i. e.*, the real average of the good and bad crops of the last five years; which would be an abnormally low average in the case of corn and wheat from 1880 to 1885. As a matter of fact, half of such returns appear to be made on the basis of a full crop instead of an average of several more or less crippled harvests,

making a bad showing and tending to a constantly declining product. The State returns are from this or similar cause of declension usually 10 per cent. too low. This is so in other countries and by various methods. For instance, the *Agricultural Gazette* of London for August 16, 1886, makes the following report of harvest estimates, the figures representing the number of returns:

Returns.	Wheat.	Barley.	Oats.	Beans.	Peas.
Over average	11	49	26	51	45
Average	52	68	80	19	52
Under average	149	88	100	69	40
Total number of returns	212	205	206	139	137

Reducing these returns to their percentage values (on the basis of numbers alone, without reference to area represented by each reporter), we have for wheat 5.2 per cent. of them over average, 24.5 per cent. average, and 70.3 under average; a very bad showing, seven-tenths being under average, and the remainder scarcely more than average.

This for a single year. The returns of a series of years, if averaged, should give a statement in which the percentage of returns "above" and "below" should be equal. The same paper gives the data for such a test, eight consecutive annual returns, of wheat as follows:

Years.	Over.	Average.	Under.
1879	1.0	24.0	75.0
1880	13.5	47.0	39.5
1881	7.6	49.7	42.7
1882	10.8	40.4	48.8
1883	8.8	30.8	60.4
1884	42.4	42.4	15.2
1885	50.4	36.9	12.7
1886	5.2	24.5	70.3
Total	139.7	295.7	364.6
Average percentage	17.0	37.0	46.0

Averaging these eight years, only about one-sixth of these returns are above an "average," while nearly one-half of all are below average. Conceding eight years to be a period long enough to construct an average, this result upsets the accuracy of the returns and establishes the tendency to underestimate.

The percentages of all other crops show the same tendency except those relating to barley. The averages for the period are as follows:

Crops reported.	Over average.	Average.	Under average.
Wheat	17	37	46
Barley	28	48	24
Oats	23	43	34
Beans	23	37	40
Peas	20	44	36
Average of the averages	22	42	36

Here the percentage "under average" for the period is nearly double that of the "over average" returns, when they should be equal. If

the basis of the comparison had been a full crop (say 100 of reports of condition) these returns would have been substantially correct. We are therefore forced to the conclusion that the reporters regularly and persistently underestimate in comparisons with an "average" crop; that the real basis of their comparison is a full crop.

In the *Mark Lane Express* for August 23 there is a statement of crop returns made to that paper, accompanied by a record of returns for ten years, making a serious under average for the whole period. In only three years of the ten is there an "over average" in wheat, oats, beans, and peas, and only four in barley, while there are seven under average years in all except barley. The number of reports or "advices" in the aggregate of the ten annual returns is 16,418, of which 33 per cent. are average, scarcely 20 over average, and 47 under average. In every one of the crops the poor returns largely outnumbered the good, as follows:

Crops reported.	Advices.	Over average.	Average.	Under average.
Wheat	3,833	793	1,106	1,934
Barley	3,763	851	1,387	1,525
Oats	3,751	735	1,410	1,606
Beans	2,597	454	732	1,411
Peas	2,474	379	800	1,295
Total	16,418	3,212	5,435	7,771

The meaning of this is, the crops have been greatly "under average" in the aggregate for the whole period. Either this is an underestimate, or ten years is not a period sufficiently long to make an average; yet it is a grave question whether a test of twenty years would not show the same result.

It has been a question on this side of the Atlantic whether the yields claimed as averages for the several crops of Great Britain are not too high. In this country there are acres that produce over 50 bushels each of wheat, while the average for the whole crop may not be more than 12. It is known that there has been no verification by census of the British product. It is made from estimates of rate of yield, and all statistical experience in this part of the world shows that any set of returns of yield will make too high an average. It is feared that the high yields of Lawes and Gilbert's experimental plots, and of other reported liberal yields on individual farms, have an undue influence in estimates of averages. If a census of yield, like that of acreage, should include every holding, and be returned from actual measurement, it is very probable that it would seriously shatter many fancied averages, as it has done in this country.

CURRENT CROP STATISTICS.

CORN.

There is a constant tendency to enlargement of the area in corn. It has been doubled in fifteen years, increasing at the rate of two to three million acres annually. The reduction in values has little effect in arresting extension of area of maize. It is realized that meats, butter, and cheese are safer and more profitable surplus products than the bulkier raw products of agriculture, at whatever rates such products have been or are liable to be sold. The uses of corn are vari-

ous, while wheat is restricted to the consumption of man. This decade, so far, has been a period of low production, of yield below the average. Since 1880 there has been only a single year (1885) in which the crop has been an average one. The yield per acre has been lower, and the price per bushel naturally higher, than in the preceding decade, as the price is made in this country, by the pressure of the home demand, almost uninfluenced by the foreign demand, which is small, and controlled by the economies of feeding, and therefore restricted by high prices in this country.

Calendar years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value of yield per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels*	
1880	1,717,434,543	62,317,842	$679,714,499	39.6	27.6	$10 91
1881	1,194,916,000	64,262,025	759,482,170	63.6	18.6	11 82
1882	1,617,025,100	65,659,546	783,867,175	48.4	24.6	11 94
1883	1,551,066,895	68,301,889	658,051,485	42.4	22.7	9 63
1884	1,795,528,000	69,683,780	640,735,560	35.7	25.8	9 19
1885	1,936,176,000	73,130,150	635,674,630	32.8	26.5	8 69
1886	1,665,441,000	75,694,208	610,311,000	36.6	22.0	8 06
Total	11,477,587,538	479,049,440	4,767,836,519	....	....	....
Annual average	1,639,655,363	68,435,634	681,119,503	41.5	24.0	9 95
Annual average for preceding ten years	1,184,486,954	43,741,331	504,571,048	42.6	27.1	11 54

Thus the average value per bushel for seven years has been 41.5 cents, against 42.6 for the ten preceding years; and the average yield per acre has been 24.0 bushels, against 27.1 bushels for the preceding period.

There is a considerable difference in the average value of the crop per acre; the comparison standing $9.95 per acre, against $11.54 per acre.

DOMESTIC DISTRIBUTION AND CONSUMPTION.

The annual investigation of the distribution of corn is made on the 1st of March, and includes estimates of the proportion of the crop remaining on the farm, which constitutes the main part of the invisible supply; the "visible supply," in commercial phrase, being that stored in public elevators. The returns also include the estimated shipments beyond county lines, the amount left within county boundaries for consumption or surplus, and the proportion deemed merchantable, showing its comparative quality, and the average local prices of merchantable and unmerchantable.

The crop of the past year, now in course of distribution and consumption, is one of reduced yield, producing less than the average of 26 bushels by nearly 4 bushels, though the acreage was larger than ever before, and the product only four times exceeded in volume—in 1879 and 1880 and in 1884 and 1885. It is one of a series of six crops, of which only one yielded slightly above the average. These were preceded by six crops all above 26 bushels per acre.

The amount on hand at this date varies with the size of the crop, especially in the twelve States of principal production, and with the commercial requirement, of which the fluctuating foreign demand is

a small element. The proportion left on the farm at this date ranges from one-third to four-tenths of the crop in different years. After the short crop of 1883, in March, 1884, the farmers' surplus was 33 per cent., and after the great crop of 1885, last March, it was almost 40 per cent. The present surplus is 36.2 per cent., almost exactly the same as that of the 1882 crop, which was a trifle larger in proportion to population than that of last year. The present remainder would be somewhat smaller but for the large crop of the previous year, from which a larger quantity of old corn than usual must enter into this surplus. Our correspondents are directed to make the last crop the basis of the percentage of surplus, including in such surplus all the grain remaining, of whatever crop.

It is understood that the quantity of corn required for consumption is not an absolute, invariable quantity, other feeding material being used with corn, and if necessary as a partial substitute for it; and yet the quantity used from the time of harvest to the 1st of March has not varied as much as the size of the respective crops. The following statement is a comparison of the amount thus used and the surplus for five years:

March 1—	Product.	On hand March 1.	Consumed or distributed.
	Bushels.	*Bushels.*	*Bushels.*
1883	1,616,996,100	587,465,943	1,029,530,157
1884	1,551,000,000	512,000,000	1,039,000,000
1885	1,795,000,000	675,000,000	1,120,000,000
1886	1,936,000,000	773,000,000	1,163,000,000
1887	1,665,000,000	603,000,000	1,062,000,000

Thus in years of nearly average crops the amount "consumed or distributed" to this date is comparatively uniform, slightly exceeding 1,000,000,000 bushels, while the large crops of 1884 and 1885, sold at low prices, were consumed in larger proportion. The rate of consumption to date is smallest in the South (58.1 per cent.), which is nearly the same as in 1884 and 1885, and more than in 1886. The winter feeding there is less for two reasons, climate and limited corn-feeding for meat-making. The use of corn in the plowing and cultivating season is larger proportionally than in any other section of the country, causing a large consumption of maize for work animals between March and July.

It is seen that 67 per cent. of the March remainder is found in the Western States, where nearly 71 per cent. of the crop was grown. For commercial purposes this section practically represents the crop. These twelve States, from West Virginia to Nebraska, inclusive, may be still further limited to seven, known as the corn-surplus States, as the only States that make any material contribution to the commercial supply. The quantity on hand in these States is less by 137,000,000 bushels than at this date last year, while the product of those States was 240,000,000 bushels greater in 1885 than in 1886. The quantity on hand in those States has averaged for five years 378,000,000 bushels, or 34,000,000 bushels more than the present remainder. As the requirement is annually increasing, the present farmers' supply is comparatively low, and the price must be considered too low for the quantity available, unless a large allowance is to be made for the present depressed status of prices. The following exhibit may

be considered a fair comparative statement of the commercially available maize at this date:

States.	1884.		1885.		1886.		1887.	
	Bushels.	*P.ct.*	*Bushels.*	*P.ct.*	*Bushels.*	*P.ct.*	*Bushels.*	*P.ct.*
Ohio	15,447,600	21.0	31,595,410	37.0	42,508,700	38.0	33,671,400	35.0
Indiana	28,686,000	30.0	37,712,520	36.0	50,157,720	38.0	43,954,150	37.0
Illinois	61,113,595	30.0	80,699,520	33.0	107,599,200	40.0	77,632,660	37.0
Iowa	40,710,960	24.0	95,988,000	38.0	92,148,480	38.0	59,654,100	30.0
Missouri	48,496,500	30.0	65,290,500	33.0	70,869,960	36.0	43,112,700	30.0
Kansas	72,576,378	42.0	70,770,000	42.0	60,188,200	38.0	40,547,840	32.0
Nebraska	41,524,349	41.0	54,945,000	45.0	58,241,700	45.0	45,635,470	43.0
Total	308,555,382	31.5	437,000,950	37.2	481,713,960	38.8	344,208,320	34.4

LOCAL DISTRIBUTION.

These estimates separate that portion of the crop intended for consumption from that shipped or to be shipped, or the home consumption from the commercial supply. The aggregate distribution always approaches or slightly surpasses an aggregate of three hundred million bushels.

Stock on hand March 1, 1887, *with local consumption and shipment.*

States and Territories.	Crop of 1886.	Stock on hand March 1, 1887.		Consumed in the county where grown.		Shipped out of the county where grown.	
	Bushels.	*Bushels.*	*P.ct.*	*Bushels.*	*P.ct.*	*Bushels.*	*P.ct.*
Maine	989,000	336,260	34.0	979,110	99.0	9,890	1.0
New Hampshire	1,364,000	531,960	39.0	1,350,360	99.0	13,640	1.0
Vermont	2,058,000	884,940	43.0	2,037,420	99.0	20,580	1.0
Massachusetts	1,922,000	615,040	32.0	1,902,780	99.0	19,220	1.0
Rhode Island	408,000	142,800	35.0	403,920	99.0	4,080	1.0
Connecticut	1,992,000	697,200	35.0	1,972,080	99.0	19,920	1.0
New York	22,426,000	8,746,140	39.0	21,753,220	97.0	672,780	3.0
New Jersey	9,418,000	3,861,380	41.0	8,193,660	87.0	1,224,340	13.0
Pennsylvania	40,545,000	15,001,650	37.0	36,085,050	89.0	4,459,950	11.0
Delaware	3,590,000	1,436,000	40.0	2,620,700	73.0	969,300	27.0
Maryland	15,039,000	6,015,600	40.0	10,527,300	70.0	4,511,700	30.0
Virginia	32,793,000	14,428,920	44.0	29,185,770	89.0	3,607,230	11.0
North Carolina	27,215,000	11,430,300	42.0	24,765,650	91.0	2,449,350	9.0
South Carolina	13,318,000	5,327,200	40.0	12,918,460	97.0	399,540	3.0
Georgia	31,197,000	14,350,620	46.0	29,949,120	96.0	1,247,880	4.0
Florida	4,597,000	2,252,530	49.0	4,321,180	94.0	275,820	6.0
Alabama	28,893,000	13,001,850	45.0	27,159,420	94.0	1,733,580	6.0
Mississippi	25,507,000	11,988,290	47.0	24,741,790	97.0	765,210	3.0
Louisiana	14,640,000	6,734,400	46.0	14,347,200	98.0	292,800	2.0
Texas	69,213,000	24,224,550	35.0	62,291,700	90.0	6,921,300	10.0
Arkansas	42,140,000	18,541,600	44.0	40,033,000	95.0	2,107,000	5.0
Tennessee	73,314,000	30,058,740	41.0	57,184,920	78.0	16,129,080	22.0
West Virginia	15,194,000	6,229,540	41.0	13,674,600	90.0	1,519,400	10.0
Kentucky	88,758,000	31,952,880	36.0	75,444,300	85.0	13,313,700	15.0
Ohio	96,204,000	33,671,400	35.0	75,039,120	78.0	21,164,880	22.0
Michigan	27,635,000	8,843,200	32.0	24,595,150	89.0	3,039,850	11.0
Indiana	118,795,000	43,954,150	37.0	89,096,250	75.0	29,698,750	25.0
Illinois	209,818,000	77,632,660	37.0	157,363,500	75.0	52,454,500	25.0
Wisconsin	28,493,000	7,408,180	26.0	26,498,490	93.0	1,994,510	7.0
Minnesota	19,905,000	6,767,700	34.0	19,108,800	96.0	796,200	4.0
Iowa	198,847,000	59,654,100	30.0	169,019,950	85.0	29,827,050	15.0
Missouri	143,709,000	43,112,700	30.0	129,338,100	90.0	14,370,900	10.0
Kansas	126,712,000	40,547,840	32.0	101,369,600	80.0	25,342,400	20.0
Nebraska	106,129,000	45,635,470	43.0	61,554,820	58.0	44,574,180	42.0
California	4,262,000	1,278,600	30.0	3,750,560	88.0	511,440	12.0
Oregon	178,000	32,040	18.0	172,660	97.0	5,340	3.0
Nevada	22,000	6,380	29.0	20,900	95.0	1,100	5.0
Colorado	938,000	337,680	36.0	769,160	82.0	168,840	18.0
Arizona	67,000	18,760	28.0	65,660	98.0	1,340	2.0
Dakota	15,805,000	5,215,650	33.0	13,908,400	88.0	1,896,600	12.0
Idaho	42,000	12,600	30.0	40,740	97.0	1,260	3.0
Montana	22,000	7,260	33.0	21,340	97.0	660	3.0
New Mexico	973,000	311,360	32.0	924,350	95.0	48,650	5.0
Utah	267,000	82,770	31.0	213,600	80.0	53,400	20.0
Washington	88,000	23,760	27.0	86,240	98.0	1,760	2.0
Total	1,665,441,000	603,344,650	36.2	1,376,800,100	82.7	288,640,900	17.3

The estimates of distribution show, as usual, that little more than one-sixth of the crop goes beyond county lines. The neighborhood distribution to local feeders is not considered. A part of the shipments go to more distant individual buyers for consumption, another portion to the cities of the West, and both city and country east of the Alleghanies, besides that which is exported to foreign countries, which is only about 3 per cent. of the crop. Excepting Tennessee and Kentucky and the seven States above named, there is no State in which the movement amounts to 10,000,000 bushels. Nebraska stands next to Illinois in this record of distribution, and Iowa and Indiana are next in prominence.

The following statement makes a comparison by sections of this distribution, showing that one-fifth of the product of the West has been handled commercially, while about one-tenth has been distributed in the Middle and Southern States:

Section.	1886.				1887.			
	Retained for county consumption.		Distribution beyond county lines.		Retained for county consumption.		Distribution beyond county lines.	
	Bushels.	*P. ct.*	*Bushels.*	*P. ct.*	*Bushels*	*P. ct.*	*Bushels.*	*P. ct.*
New England	8,682,630	99.7	27,370	0.3	8,645,670	99.0	87,330	1.0
Middle	76,196,480	90.8	7,711,520	9.2	68,652,630	90.4	7,326,370	9.6
Southern	354,744,310	90.2	38,581,690	9.8	337,425,510	89.3	40,440,490	10.7
Western	1,140,125,770	79.8	288,187,230	20.2	942,102,680	79.8	238,096,320	20.2
Pacific	3,409,040	85.5	578,960	14.5	3,923,220	88.4	516,780	11.6
Nevada, Colorado, and Territories	16,019,190	89.3	1,911,810	10.7	16,050,390	88.1	2,173,610	11.9
Total	1,599,177,420	82.6	336,998,580	17.4	1,376,800,100	82.7	288,640,900	17.3

The distribution of the crop of 1886 to date is less than the shipments of two years ago by only 10,000,000 bushels, though the crop of 1884 was much larger.

PROPORTION MERCHANTABLE.

The crop of 1886 ripened well, with very little frosted, and only 14 per cent. from any cause deemed unmerchantable. The proportion of sound corn, commercially designated as "merchantable," was 86 per cent. Two years ago the crop was even better ripened, averaging 89 per cent. merchantable. The great crop of 1885 was slightly below average in quality, as only 78 per cent. was estimated merchantable, from frost and other causes. The crop of 1883 suffered severely from frost, only 60 per cent. being merchantable, instead of 80 in an average year.

The largest proportion of the crop consumed at this date is on the Pacific coast and in the Territories, but the quantity is so small that the fact has little significance.

The Western States uniformly show the highest rate of consumption and the largest proportion of the crop consumed, with the above unimportant exception. This is due to feeding for meat, mutton, and milk. The Eastern States stand next, and the Middle States next to the cotton belt. It is also understood that shipments eastward are from this region.

The average consumption of the past crop to date is 63.8 per cent.; for five years, 63.2 per cent. Thus the average consumption to March is ordinary; a very little less than two-thirds of the crop. The fol-

lowing statement shows the proportion used for five years, by sections:

Sections.	1883.	1884.	1885.	1886.	1887.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
New England	70.2	66.2	62.9	61.6	63.3
Middle	62.6	68.2	63.4	59.3	61.8
Southern	56.5	58.6	58.6	54.6	58.1
Western	66.2	69.3	63.3	61.6	65.6
Pacific	74.6	70.7	60.4	68.4	70.5
Nevada, Colorado, and Territories	65.0	70.2	65.5	63.3	67.0

The following statement shows the remainder in the hands of the farmers each year, averaging about 640,000,000 bushels, or 37,000,000 bushels more than the quantity now on hand:

Sections.	1884.		1885.		1886.		1887.	
	Bushels.	*P. ct.*	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*
New England	2,843,390	33.8	3,132,944	37.1	3,344,420	38.4	3,208,200	36.7
Middle	21,890,705	31.8	29,712,800	36.6	34,165,780	40.7	29,045,170	38.2
Southern	137,922,031	41.4	144,798,860	41.4	178,606,340	45.4	158,354,600	41.9
Western	346,771,467	30.7	490,021,950	36.7	549,084,080	38.4	405,409,820	34.4
Pacific	760,128	29.3	1,965,920	39.6	1,258,400	31.6	1,310,640	29.5
Nevada, Colorado, and Territories	2,036,282	29.8	5,578,190	34.5	6,587,470	36.7	6,016,220	33.0
Total	512,224,003	33.0	675,210,664	37.6	773,046,490	39.9	603,344,650	36.2

The proportion of the merchantable and unmerchantable, respectively, in recent years, has been as follows:

	1883.	1884.	1885.	1886.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Merchantable	60	89	78	86
Unmerchantable	40	11	22	14

Proportion and value per bushel and total value of merchantable and unmerchantable corn.

States and Territories.	Merchantable.			Unmerchantable.		
	Bushels.	Price per bushel.	Value.	Bushels.	Price per bushel.	Value.
		Cents.	*Dollars.*		*Cents.*	*Dollars.*
Maine	761,530	74	563,532	227,470	42	95,587
New Hampshire	1,036,640	75	777,480	327,360	40	130,944
Vermont	1,749,300	71	1,242,003	308,700	36	111,18
Massachusetts	1,710,580	70	1,197,406	211,420	33	69,76
Rhode Island	363,120	74	268,709	44,880	34	15,25
Connecticut	1,693,200	68	1,151,376	298,800	32	95,61
New York	18,837,840	61	11,491,082	3,588,160	30	1,076,44
New Jersey	8,193,660	53	4,342,640	1,224,340	31	379,54
Pennsylvania	34,057,800	51	17,369,478	6,487,200	27	1,751,54
Delaware	3,159,200	46	1,453,232	430,800	28	120,62
Maryland	13,384,710	46	6,156,967	1,654,290	27	446,65
Virginia	26,234,400	52	13,641,888	6,558,600	29	1,901,99
North Carolina	22,316,300	63	14,059,269	4,898,700	30	1,469,61
South Carolina	11,586,660	64	7,415,462	1,731,340	35	605,96
Georgia	27,453,360	64	17,570,150	3,743,640	33	1,235,40
Florida	4,045,360	75	3,034,020	551,640	31	171,00
Alabama	26,003,700	64	16,642,368	2,889,300	30	866,79
Mississippi	22,956,300	62	14,232,906	2,550,700	30	765,21
Louisiana	12,444,000	60	7,466,400	2,196,000	30	658,80
Texas	52,601,880	63	33,139,184	16,611,120	33	5,481,67
Arkansas	37,926,000	52	19,721,520	4,214,000	29	1,222,06
Tennessee	66,715,740	43	28,687,768	6,598,260	25	1,649,56
West Virginia	12,762,960	45	5,743,332	2,431,040	25	607,76

Proportion and value per bushel and total value of merchantable and unmerchantable corn—Continued.

States and Territories.	Merchantable.			Unmerchantable.		
	Bushels.	Price per bushel.	Value.	Bushels.	Price per bushel.	Value.
		Cents.	*Dollars.*		*Cents.*	*Dollars.*
Kentucky	77,219,460	36	27,799,006	11,538,540	24	2,769,250
Ohio	82,735,440	37	30,612,113	13,468,560	23	3,097,769
Michigan	22,108,000	42	9,285,360	5,527,000	25	1,381,750
Indiana	106,915,500	34	36,351,270	11,879,500	22	2,613,490
Illinois	182,541,660	32	58,413,331	27,276,340	22	6,000,795
Wisconsin	23,649,190	39	9,223,184	4,843,810	27	1,307,829
Minnesota	17,516,400	35	6,130,740	2,388,600	23	549,378
Iowa	174,985,360	31	54,245,462	23,861,640	24	5,726,794
Missouri	120,715,560	32	38,628,979	22,993,440	25	5,748,360
Kansas	103,903,840	28	29,093,075	22,808,160	23	5,245,877
Nebraska	97,638,680	21	20,504,123	8,490,320	13	1,103,742
California	3,835,800	65	2,493,270	426,200	45	191,790
Oregon	156,640	75	117,480	21,360	41	8,758
Nevada	19,800	80	15,840	2,200	50	1,100
Colorado	816,060	53	432,512	121,940	28	34,143
Arizona	60,300	80	48,240	6,700	45	3,015
Dakota	14,540,600	40	5,816,240	1,264,400	20	252,880
Idaho	35,700	67	23,919	6,300	35	2,205
Montana	19,580	70	13,706	2,420	37	895
New Mexico	797,860	77	614,352	175,140	40	70,056
Utah	160,200	67	107,334	106,800	33	35,244
Washington	80,960	67	54,243	7,040	30	2,112
Total	1,438,446,830	38.7	557,391,951	226,994,170	25.1	57,076,145

VALUE OF THE CROP.

The value of the crop, on the basis of March prices of merchantable and unmerchantable corn separately estimated, is thus stated:

Merchantable, at 38.7 cents	$557,391,951
Unmerchantable, at 25.1 cents	57,076,145
Total value	614,468,096
Value as estimated December 1	610,311,000

The value has slightly increased in some districts, mainly dependent on local supply; while in commercial markets, Chicago notably, the value of December is scarcely sustained, though the decline is only a small fraction.

The value of merchantable corn is reported 2.7 cents higher than a year ago; the unmerchantable at 3.1 cents higher.

The farm prices (reported in December) averaged 36.6 cents per bushel. This average is higher than those of 1877 and 1878, and also those of 1884 and 1885. The following statement includes annual averages for principal States and for the United States:

States.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Kentucky	$0 30	$0 32	$0 40	$0 37	$0 38	$0 70	$0 52	$0 42	$0 43	$0 35	$0 34
Ohio	38	40	33	39	41	61	62	47	41	32	35
Michigan	52	39	38	45	46	63	59	52	40	34	38
Indiana	34	34	27	34	40	60	48	41	34	29	32
Illinois	31	29	25	31	36	58	47	40	31	28	31
Wisconsin	41	33	29	39	39	54	53	48	34	34	37
Minnesota	40	38	29	27	36	53	45	43	33	32	34
Iowa	25	25	16	24	26	44	38	32	23	24	30
Missouri	28	27	26	25	26	65	39	35	26	25	31
Kansas	24	21	19	27	29	58	37	26	22	24	27
Nebraska	27	18	16	21	25	39	33	24	18	19	20
Dakota	......	......	......	......	......	......	51	45	30	28	37
United States	37	35.8	31.8	37.5	39.6	63.6	48.4	42.4	35.7	32.8	36.6

Compared with average farm prices the actual export prices are given below, the years named being fiscal years following the year of production:

Years ended June 30—	Price.	Years ended June 30—	Price.
1877	$0 58.7	1882	$0 66.8
1878	56.2	1883	68.4
1879	47.1	1884	61.1
1880	54.3	1885	54.(
1881	55.2	1886	49.8

EXPORTATION.

The exportation of corn as grain and meal amounted to only about half of 1 per cent. of the crop in 1860. During the next ten years it averaged little more than 1 per cent. Between 1870 and 1880, especially in the latter half of the period, when the harvests of Western Europe (not maize) were greatly impaired and prices of all feeding-stuffs high, exports were heavy. The annual range of these exports was quite extraordinary: from about 2,000,000 bushels in 187(to nearly 100,000,000 in 1880. This difference is mainly accountec for by the fact that the export price dropped from 93 to 54 cent: per bushel. With an increase of exportation almost fifty fold th price was about half as high, showing how little influence the larges foreign demand ever enjoyed had upon prices. The following statement shows how much corn and corn-meal in its equivalent to cor have been exported since 1880:

Years ended June 30—	Quantity.			Value.		
	Corn.	Meal.	Total.	Corn.	Meal.	Total.
	Bushels.	*Bushels.*	*Bushels.*	*Dollars.*	*Dollars.*	*Dollars.*
1881	91,908,175	1,739,972	93,648,147	50,702,669	1,270,200	51,972,8
1882	43,184,915	1,155,768	44,340,683	28,845,830	994,201	29,840,0
1883	40,586,825	1,068,828	41,655,653	27,756,082	980,798	28,736,8
1884	45,247,490	1,011,116	46,258,606	27,648,044	818,739	28,466,7
1885	51,834,416	1,042,040	52,876,456	28,003,863	816,459	28,820,3
1886	63,655,433	1,174,184	64,829,617	31,730,922	858,370	32,589,2
Total	336,417,254	7,191,908	343,609,162	194,687,410	5,738,767	200,426,1
Annual average	56,069,542	1,198,651	57,268,193	32,447,902	956,461	33,404,3
Annual average, 1871–'80	53,643,470	1,434,690	55,078,160	32,133,519	1,264,755	33,398,2
Annual average, 1861–'70	10,061,108	1,012,701	11,073,809	8,205,501	1,266,976	9,472,4

WHEAT.

The area of wheat has increased 50 per cent. since 1874, when th country passed France in wheat production, and assumed the fir rank in wheat-growing among the nations. There are wheat lanc yet to occupy, and the disposition is strong to extend the cultivatio notwithstanding the necessary reduction in prices caused by a plethoi in international markets. There has been a halt, however, at certa points, though not all along the line of progress. The problem ‹ cheaper production commands an effort at solution by many who a

ınwilling to adopt a slower movement in extension of wheat-growing. [he following statement shows the status of production since 1870:

Calendar years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value of yield per acre.
	Bushels.	*Acres.*	*Dollars.*	*Cents.*	*Bushels.*	*Dollars.*
880	498,549,868	37,986,717	474,201,850	95.1	13.1	$12 48
881	383,280,090	37,709,020	456,880,427	119.3	10.2	12 12
882	504,185,470	37,067,194	444,602,125	88.2	13.6	11 99
883	421,086,160	36,455,593	383,649,272	91.0	11.6	10 52
884	512,765,000	39,475,885	330,862,260	64.5	13.0	8 38
885	357,112,000	34,189,246	275,320,390	77.1	10.4	8 05
886	457,218,000	36,806,184	314,226,020	68.7	12.4	8 54
Total	3,134,196,588	259,689,839	2,679,742,344	....	....	....
nnual average	447,742,370	37,098,548	382,820,335	85.5	12.1	10 32
nnual average for preceding ten years	312,152,728	25,187,414	327,407,258	104.9	12.4	13 00

It is sometimes assumed that the yield of wheat is declining in this ountry. This conclusion is not warranted by the facts. The averge for six years past is 12.1 bushels per acre, ranging from 10.4 to 3.6 annually. The average of the preceding ten years was 12.4. Almost any period of five to eight years has heretofore made an verage very slightly exceeding 12 bushels. The older wheat-growng States make larger averages than the newly-settled regions, not ecause the land is richer, but because it is more thoroughly cultiated. In the future, as rotation and thorough culture prevail, the verage rate of yield must be expected to increase, as it has done in ome sections already.

While the yield is unimpaired, the reduction in price has been serius, so that the value of the product per acre has been only $10.32 gainst $13 for the preceding decade, a reduction of more than 20 er cent., nearly 20 cents per bushel of the farm price.

The estimates of production are made in advance of the record of onsumption, and, of course, in the absence of the requirements of he export trade. For eight years past the consumption has been alculated on a basis fixed by careful tests, and the distribution has lways run parallel with the estimated production, with the slightest ossible discrepancy. In the following table, including the crops nade since the last census, the aggregate production is placed at ,178,427,620 bushels, and the distribution makes an aggregate of ,164,034,279 bushels. This leaves an apparent surplus of about 4,000,000 for the whole period, which has all been absorbed, and robably more, by losses in the lakes and by fire, showing on this asis of consumption that the estimates, which are often held by peculators to be too high, are really somewhat too low, though renarkably close. The table is as follows:

Years.	Production.	For food.	For seed.	Exportation.	Per cent. of exportation.	Total distribution.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*		*Bushels.*
81	383,280,090	235,249,812	55,215,573	121,892,389	32	412,357,774
82	504,185,470	255,500,000	52,770,312	147,811,316	29	456,081,628
83	421,086,160	259,500,000	54,683,389	111,534,182	26	425,717,571
84	512,763,900	265,000,000	55,266,239	132,570,367	26	452,836,606
85	357,112,000	271,000,000	51,474,906	94,565,794	26	417,040,700
Total	2,178,427,620	1,286,249,812	269,410,419	608,374,048	....	2,164,034,279
Average	435,685,524	257,249,962	53,882,084	121,674,810	27.9	432,806,856

CONSUMPTION AND DISTRIBUTION.

The proportion of wheat remaining in the hands of farmers March 1, 1887, is estimated at 26.7 per cent. of the volume of the crop of 1886. This includes all on hand, whether of the last crop or any older surplus. This is slightly less than the average proportion for five years past. Only once has the record been higher than three-tenths; it was 33.1 March 1, 1885, after the great crop of 1884. In 1883 it was 28.5; in 1884, 28.4; last March, 30.1 per cent. of a very small crop. The crop record was 100,000,000 bushels more than that of 1885; the farmers' stock March 1, only 15,000,000 bushels more than that of the preceding March. The "visible supply," or commercial stock, is 5,000,000 bushels more than last year—57,000,000 against 52,000,000 bushels. In addition to these sources of supply there are further stocks in flouring-mills, and en route from the mill to the bakery and household storerooms, which are not here given. A small amount may be on mercantile storage between the farmer's bin and the elevator list of the commercial authorities. Were such stocks the same each year they need not be considered in a comparative statement. As to the milling stocks, it is evident that they were greater last year than this. Had millers stocked up as in the autumn of 1885, the farmers' stocks would doubtless have been lower than last year.

These estimates have been made for seven years, and the average in farmers' hands has been 129,000,000 bushels; 7,000,000 bushels more than the present stock. The figures are, in round numbers, as follows:

	Bushels.
1887	122,000,000
1886	107,000,000
1885	169,000,000
1884	119,000,000
1883	143,000,000
1882	98,000,000
1881	145,000,000

Surplus and distribution by groups of States.

Sections.	Crop of 1886.	Stock on hand March 1, 1887.		Retained for county consumption.		Distributed beyond county lines.	
	Bushels.	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*
New England	1,232,000	530,280	43	1,219,680	99	12,320	1
Middle	32,785,000	11,676,190	35.6	19,024,680	58	13,760,320	42
Southern	35,534,000	7,532,180	21.2	21,074,070	59.3	14,459,930	40.7
Western	294,244,000	81,572,620	27.7	124,452,270	42.3	169,791,730	57.7
Pacific	47,298,000	9,904,920	20.9	12,408,810	26.2	34,889,190	73.[illegible]
Nevada, Colorado, and Territories	46,125,000	11,050,080	24	15,859,380	34.4	30,265,620	65.[illegible]
Total	457,218,000	122,266,270	26.7	194,038,890	42.4	263,179,110	57.[illegible]

A larger volume of wheat has gone into distribution from this crop than from the last, though the proportion of the crop has been nearly the same; about 58 per cent. of all.

Stock on hand and amount retained for home consumption, March 1, 1887.

States and Territories.	Crop of 1886.	Stock on hand March 1, 1887.		Consumed in county where grown.		Shipped out of county where grown	
	Bushels.	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*
Maine	600,000	240,000	40	594,000	99	6,000	1
New Hampshire	169,000	74,360	44	167,310	99	1,690	1
Vermont	410,000	196,800	48	405,900	99	4,100	1
Massachusetts	17,000	5,440	32	16,830	99	170	1
Connecticut	36,000	13,680	38	35,640	99	360	1
New York	11,093,000	4,215,340	38	6,544,870	59	4,548,130	41
New Jersey	2,260,000	836,200	37	1,627,200	72	632,800	28
Pennsylvania	18,255,000	6,389,250	35	10,405,350	57	7,849,650	43
Delaware	1,177,000	235,400	20	447,260	38	729,740	62
Maryland	7,194,000	1,582,680	22	2,230,140	31	4,963,860	69
Virginia	5,581,000	1,283,630	23	2,623,070	47	2,957,930	53
North Carolina	3,209,000	641,800	20	2,823,920	88	385,080	12
South Carolina	936,000	168,480	18	842,400	90	93,600	10
Georgia	1,690,000	338,000	20	1,470,300	87	219,700	13
Alabama	1,529,000	214,060	14	1,376,100	90	152,900	10
Mississippi	173,000	27,680	16	164,350	95	8,650	5
Texas	5,383,000	968,940	18	3,660,440	68	1,722,560	32
Arkansas	1,815,000	381,150	21	1,470,150	81	344,850	19
Tennessee	8,024,000	1,925,760	24	4,413,200	55	3,610,800	45
West Virginia	3,061,000	918,300	30	1,836,600	60	1,224,400	40
Kentucky	12,405,000	3,101,250	25	5,334,150	43	7,070,850	57
Ohio	40,362,000	12,108,600	30	16,144,800	40	24,217,200	60
Michigan	26,572,000	6,377,280	24	8,768,760	33	17,803,240	67
Indiana	40,255,000	10,466,300	26	14,089,250	35	26,165,750	65
Illinois	27,562,000	6,890,500	25	13,781,000	50	13,781,000	50
Wisconsin	14,725,000	4,270,250	29	7,068,000	48	7,657,000	52
Minnesota	42,856,000	12,856,800	30	11,999,680	28	30,856,320	72
Iowa	32,455,000	9,411,950	29	18,174,800	56	14,280,200	44
Missouri	21,986,000	5,716,360	26	12,532,020	57	9,453,980	43
Kansas	14,556,000	3,347,880	23	7,569,120	52	6,986,880	48
Nebraska	17,449,000	6,107,150	35	7,154,090	41	10,294,910	59
California	36,165,000	7,233,000	20	9,402,900	26	26,762,100	74
Oregon	11,133,000	2,671,920	24	3,005,910	27	8,127,090	73
Nevada	72,000	15,840	22	54,000	75	18,000	25
Colorado	2,419,000	774,080	32	1,136,930	47	1,282,070	53
Arizona	297,000	71,280	24	249,480	84	47,520	16
Dakota	30,704,000	6,754,880	22	6,447,840	21	24,256,160	79
Idaho	1,039,000	259,750	25	696,130	67	342,870	33
Montana	1,509,000	347,070	23	829,950	55	679,050	45
New Mexico	921,000	230,250	25	782,850	85	138,150	15
Utah	1,541,000	539,350	35	924,600	60	616,400	40
Washington	7,560,000	2,041,200	27	4,687,200	62	2,872,800	38
Wyoming	63,000	16,380	26	50,400	80	12,600	20
Total	457,218,000	122,266,270	26.7	194,038,890	42.4	263,179,110	57.6

VALUE OF THE CROP.

Average price of wheat for the years 1875–1886.

State.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Kentucky	$1 05	$1 00	$0 99	$0 76	$1 08	$0 93	$1 31	$0 90	$0 95	$0 74	$0 95	$0 72
Ohio	1 09	1 14	1 24	86	1 20	1 02	1 29	95	99	75	91	74
Michigan	1 15	1 16	1 22	85	1 17	97	1 25	90	96	74	84	73
Indiana	97	1 02	1 13	81	1 17	99	1 27	90	95	67	86	70
Illinois	91	93	1 04	75	1 07	95	1 22	85	92	63	81	69
Wisconsin	91	1 01	93	67	1 04	1 00	1 19	90	88	60	76	68
Minnesota	86	90	91	51	94	87	1 06	82	80	50	70	61
Iowa	71	90	87	50	92	82	1 06	70	80	55	67	60
Missouri	95	89	1 00	67	1 01	89	1 19	85	88	62	77	63
Kansas	87	86	82	59	89	70	1 05	67	78	45	65	58
Nebraska	64	73	83	49	84	73	97	67	70	42	57	47
Dakota	......	......	......	......	......	......	......	80	72	46	63	52
United States	1 00	1 03.7	1 08.2	77.7	1 10.8	95.1	1 19.3	88.2	91	64.5	77.1	68.7

The average export price is as follows for twelve years:

Years.	Average price.	Years.	Average price.
1874-'75	$1 12	1880-'81	$1 11
1875-'76	1 24	1881-'82	1 19
1876-'77	1 17	1882-'83	1 13
1877-'78	1 34	1883-'84	1 07
1878-'79	1 07	1884-'85	86
1879-'80	1 24	1885-'86	87

The farm value of the crop of 1885 was $275,320,390 in December, or 77.1 cents per bushel.

WEIGHT PER BUSHEL.

The weight of the crop of 1886 surpasses very slightly that of 1884, being 58.4 pounds per bushel against 58.3. The estimated weight of the crop of 1885 was only 57 pounds. Counting high-grade wheat, averaging 60 pounds per bushel, the present crop is equal to 444,000,000 bushels, or 105,000,000 bushels more than the crop of 1885, calculated on the same basis. The following statement records this estimate by States:

States and Territories.	Weight per bushel.	Bushels of crop.	Weight.	Bushels of 60 pounds.
	Pounds.		*Pounds.*	
Maine	58	600,000	34,800,000	580,000
New Hampshire	58	169,000	9,802,000	163,367
Vermont	58	410,000	23,780,000	396,333
Massachusetts	59	17,000	1,003,000	16,717
Connecticut	58	36,000	2,088,000	34,800
New York	59	11,093,000	654,487,000	10,908,117
New Jersey	59	2,260,000	133,340,000	2,222,333
Pennsylvania	59	18,255,000	1,077,045,000	17,950,750
Delaware	57	1,177,000	67,089,000	1,118,150
Maryland	58	7,194,000	417,252,000	6,954,200
Virginia	57	5,581,000	318,117,000	5,301,950
North Carolina	56	3,209,000	179,704,000	2,995,067
South Carolina	55	936,000	51,480,000	858,000
Georgia	55	1,690,000	92,950,000	1,549,167
Alabama	57	1,529,000	87,153,000	1,452,550
Mississippi	55	173,000	9,515,000	158,583
Texas	58	5,383,000	312,214,000	5,203,567
Arkansas	56	1,815,000	101,640,000	1,694,000
Tennessee	55	8,024,000	441,320,000	7,355,333
West Virginia	58	3,061,000	177,538,000	2,958,967
Kentucky	59	12,405,000	731,895,000	12,198,250
Ohio	59	40,362,000	2,381,358,000	39,689,300
Michigan	59	26,572,000	1,567,748,000	26,129,133
Indiana	59	40,255,000	2,375,045,000	39,584,083
Illinois	59	27,562,000	1,626,158,000	27,102,633
Wisconsin	58	14,725,000	854,050,000	14,234,167
Minnesota	58	42,856,000	2,485,648,000	41,427,467
Iowa	58	32,455,000	1,882,390,000	31,373,167
Missouri	59	21,986,000	1,297,174,000	21,619,567
Kansas	56	14,556,000	815,136,000	13,585,600
Nebraska	58	17,449,000	1,012,042,000	16,867,367
California	59	36,165,000	2,133,735,000	35,562,250
Oregon	60	11,133,000	667,980,000	11,133,000
Nevada	60	72,000	4,320,000	72,000
Colorado	61	2,419,000	147,559,000	2,459,317
Arizona	59	297,000	17,523,000	292,050
Dakota	57	30,704,000	1,750,128,000	29,168,800
Idaho	59	1,039,000	61,301,000	1,021,683
Montana	59	1,509,000	89,031,000	1,483,850
New Mexico	58	921,000	53,418,000	890,300
Utah	59	1,541,000	90,919,000	1,515,317
Washington	59	7,560,000	446,040,000	7,434,000
Wyoming	59	63,000	3,717,000	61,950
Total	58.4	457,218,000	26,686,632,000	444,777,209

EXPORTATION.

The exportation of wheat has a record as old as the Government of the United States. In the eighteenth century and up to 1860 flour took the lead of wheat in quantity. Since that date grain in bulk has been greatly in excess. Recently the tendency is manifestly favorable to a larger proportion of exports in the form of flour.

From 1826 to 1855 the average exportation was less than 9,000,000 bushels. After 1860 there was rapid increase in the volume of wheat exported, rising to 20, to 30, and culminating at 33 per cent., or one-third of the crop shipped abroad for a period of six years. The last six years, however, mark a period of decline to 26 per cent. It is doubtful if one-fourth of the crop can hereafter be exported, as other wheat-growing nations will doubtless divide the trade, which is limited by an uncertain measure of deficiency.

The following table shows the exportation of wheat, and flour in its equivalent of wheat, by decennial periods from 1831 to 1880 and by years from 1881 to 1886:

Decennial periods.	Quantity.			Value.		
	Wheat.	Flour.	Total wheat.	Wheat.	Flour.	Total value.
	Bushels.	*Bushels.*	*Bushels.*	*Dollars.*	*Dollars.*	*Dollars.*
1831-'40	2,456,986	46,674,480	49,131,466	2,554,432	56,579,601	59,134,033
1841-'50	13,131,506	92,797,625	105,929,131	15,701,878	100,431,897	116,133,775
1851-'60	55,255,528	144,638,930	199,894,458	75,208,680	180,143,666	255,352,346
1861-'70	220,115,995	156,246,370	376,362,365	295,998,699	225,713,645	521,712,344
1871-'80	667,429,799	186,782,602	854,212,401	830,177,921	250,492,748	1,080,670,669
1881	150,565,477	35,756,037	186,321,514	167,698,485	45,047,257	212,745,742
1882	95,271,802	26,620,587	121,892,389	112,929,718	36,375,055	149,304,773
1883	106,385,828	41,425,488	147,811,316	119,879,341	54,824,459	174,703,800
1884	70,349,012	41,185,170	111,534,182	75,026,678	51,139,696	126,166,374
1885	84,653,714	47,916,653	132,570,367	72,933,097	52,146,336	125,079,433
1886	57,759,209	36,806,585	94,565,794	50,262,715	38,442,955	88,705,670

OATS.

The tendency is towards enlargement of the cultivation of oats, as in the case of corn. The other grains are used almost exclusively for human consumption, and do not, therefore, admit of such extension. An increase of about half a million acres occurred in 1886. The season was moderately favorable, the averages of condition being: June, 95.9; July, 88.8; August, 87.4; September, 90.9. As in the case of spring wheat, there was a sharp decline in July; in August condition remained nearly stationary, and on the 1st of September a material improvement was shown. The product of oats is (in round numbers) 624,000,000 bushels, 5,000,000 less than in 1885, grown on an area of over 23,000,000 acres, and valued at $186,000,000. The average yield

is 26.4 bushels, against 27.6 bushels. The average value is higher—29.8 cents per bushel against 28.5 cents in 1885.

States and Territories.	Acres.	Bushels.	Value.
Maine	90,490	2,701,000	$1,080,400
New Hampshire	32,766	1,081,000	443,210
Vermont	106,656	3,844,000	1,422,280
Massachusetts	24,267	738,000	324,720
Rhode Island	6,353	184,000	80,960
Connecticut	39,027	1,123,000	471,660
New York	1,399,097	40,223,000	14,078,050
New Jersey	137,455	3,734,000	1,344,240
Pennsylvania	1,317,063	37,759,000	12,838,060
Delaware	21,409	492,000	172,200
Maryland	113,322	2,470,000	815,100
Virginia	633,655	8,577,000	2,916,180
North Carolina	635,064	6,276,000	2,824,200
South Carolina	393,265	3,440,000	2,132,800
Georgia	589,001	5,301,000	3,180,600
Florida	51,467	489,000	308,070
Alabama	409,807	4,718,000	2,925,160
Mississippi	355,001	3,368,000	2,121,840
Louisiana	36,138	361,000	187,720
Texas	552,966	11,369,000	5,684,500
Arkansas	263,848	4,749,000	1,994,580
Tennessee	638,699	7,920,000	2,534,400
West Virginia	139,419	2,803,000	840,900
Kentucky	486,630	10,219,000	3,270,080
Ohio	983,606	31,850,000	8,918,000
Michigan	628,116	18,521,000	6,297,140
Indiana	1,034,923	31,798,000	8,585,460
Illinois	3,257,180	103,649,000	26,948,740
Wisconsin	1,398,349	39,656,000	11,103,680
Minnesota	1,184,032	40,735,000	10,183,750
Iowa	2,298,752	78,454,000	18,044,420
Missouri	1,305,884	30,577,000	7,644,250
Kansas	964,930	25,516,000	6,379,000
Nebraska	742,051	21,865,000	4,154,350
California	80,348	2,317,000	1,019,480
Oregon	199,199	5,102,000	2,142,840
Nevada	7,858	250,000	125,000
Colorado	48,207	1,591,000	668,220
Dakota	825,600	20,651,000	6,195,300
Idaho	34,770	1,078,000	592,900
Montana	56,774	1,987,000	1,092,850
New Mexico	15,087	528,000	253,440
Utah	28,794	858,000	343,200
Washington	88,393	3,126,000	1,406,700
Wyoming	2,756	86,000	47,300
Total	23,658,474	624,134,000	186,137,930

The following statement of former crops shows that the average yield since 1880 has been less than the average of the previous decade, and the price lower, as is the case with nearly all farm products:

Calendar years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value of yield per acre.
	Bushels.	*Acres.*	*Dollars.*	*Cents.*	*Bushels.*	*Dollars.*
1880	417,885,380	16,187,977	150,243,565	36.0	25.8	9 28
1881	416,481,000	16,831,600	193,198,970	46.4	24.7	11 48
1882	488,250,610	18,494,691	182,978,022	37.5	26.4	9 64
1883	571,302,400	20,324,962	187,040,264	33.0	28.1	9 27
1884	583,628,000	21,300,917	161,528,470	28.0	27.4	7 58
1885	629,409,000	22,783,630	179,631,860	28.5	27.6	7 88
1886	624,134,000	23,658,474	186,137,930	29.8	26.4	7 87
Total	3,731,090,390	139,582,251	1,240,759,081	....	....	....
Annual average	533,012,913	19,940,322	177,251,297	33.3	26.7	8 89
Annual average for preceding ten years	314,441,178	11,076,822	111,075,223	35.3	28.4	10 03

RYE.

This grain is not popular in the United States. It is used to a limited extent for bread in combination with maize in New England and by the people coming from continental Europe, and in a still smaller proportion for distillation. The crop of 1886 was about an average, 26,000,000 bushels in round numbers, yielding a little less than 12 bushels per acre. The following statement shows the previous production and value:

Calendar years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value of yield per acre.
	Bushels.	*Acres.*	*Dollars.*	*Cents.*	*Bushels.*	*Dollars.*
1880	24,540,829	1,767,619	18,564,560	75.6	13.9	10 50
1881	20,704,950	1,789,100	19,327,415	93.3	11.6	10 80
1882	29,960,037	2,227,889	18,439,194	61.5	13.4	8 28
1883	28,058,583	2,314,754	16,300,503	58.0	12.1	7 04
1884	28,640,000	2,343,963	14,857,040	52.0	12.2	6 34
1885	21,756,000	2,129,301	12,594,820	57.9	10.2	5 92
Total	153,660,399	12,572,626	100,083,532	....	....	....
Annual average	25,610,067	2,095,438	16,680,589	65.1	12.2	7 96
Annual average for preceding ten years	18,460,985	1,305,061	12,945,136	70.1	14.1	9 92

BARLEY.

This crop is one of restricted area and use. It is not sufficiently abundant or cheap to take the place of corn and other cattle grains, and is not used except in a very limited way in competition with other breadstuffs. California, however, is a local exception to this statement, producing more than a fourth of the crop, and using it extensively in feeding. New York, the Northwest, and the Pacific coast region produce nearly all of it. The crop of 1886 was a full average, or over 22 bushels per acre, and the product nearly 60,000,000 bushels. The following statement shows the course of production and values since 1870:

Calendar years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value of yield per acre.
	Bushels.	*Acres.*	*Dollars.*	*Cents.*	*Bushels.*	*Dollars.*
1880	45,165,346	1,843,329	30,090,742	66.6	24.5	16 32
1881	41,161,330	1,967,510	33,862,513	82.3	20.9	17 21
1882	48,953,926	2,272,103	30,768,015	62.8	21.5	13 54
1883	50,136,097	2,379,009	29,420,423	58.7	21.1	12 38
1884	61,203,000	2,608,818	29,779,170	48.7	23.5	11 41
1885	58,360,000	2,729,359	32,867,696	56.3	21.4	12 04
Total	304,979,699	13,800,128	186,788,559	....	....	....
Annual average	50,829,950	2,300,021	31,131,427	61.2	22.1	13 54
Annual average for preceding ten years	33,704,652	1,529,357	24,885,503	73.8	22.0	16 27

BUCKWHEAT.

This, smallest in area and product of the principal cereals, was somewhat under average in yield, considerably less than the average of the preceding year, producing scarcely 10,000,000 bushels. Two-thirds of the crop is grown in New York and Pennsylvania, for consumption in the form of breakfast batter-cakes, and used largely in the central cities and towns of the Middle States. The following record is made for product and value:

Calendar years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value of yield per acre.
	Bushels.	*Acres.*	*Dollars.*	*Cents.*	*Bushels.*	*Dollars.*
1880	14,617,535	822,802	8,682,488	59.4	17.7	10 55
1881	9,486,200	828,815	8,205,705	86.5	11.4	9 90
1882	11,019,353	847,112	8,038,862	72.9	13.1	9 48
1883	7,668,954	857,349	6,303,980	82.2	8.9	7 35
1884	11,116,000	879,403	6,549,020	59.0	12.6	7 45
1885	12,626,000	914,394	7,057,363	55.9	13.8	7 72
Total	66,534,042	5,149,875	44,837,418	....	....	....
Annual average	11,089,007	858,313	7,472,903	67.4	12.9	8 71
Annual average for preceding ten years	9,747,272	551,104	6,972,974	71.5	17.7	12 65

ALL CEREALS.

The increase in cereals is shown by the figures below, the average of the decade ended in 1879 being 1,872,993,769, and that of the last six years 2,686,875,943 bushels, an increase of over 30 per cent., which is decidedly in advance of the ratio of increase of population, and serves to explain the relative cheapness of grain, aside from the general tendency to lower prices. The product for 1886 is about 2,842,000,000 bushels, or 47 bushels per capita of present population, and greater than the average of the period since the general census. The record is as follows up to 1885:

Calendar years.	Bushels.	Acres.	Value.
1880	2,718,193,501	120,926,286	$1,361,497,704
1881	2,066,029,570	123,388,070	1,470,957,200
1882	2,699,394,496	126,568,535	1,468,693,393
1883	2,629,319,089	130,633,556	1,280,765,927
1884	2,992,880,000	136,292,766	1,184,311,520
1885	3,015,439,000	135,876,080	1,143,146,759
Total	16,121,255,656	773,685,293	7,909,372,503
Average of six years	2,686,875,943	128,947,549	1,318,228,751
Average of ten preceding years	1,872,993,769	83,391,088	987,857,142

POTATOES.

The potato (*Solanum tuberosum*) is grown in all parts of the country, not very extensively in the South, where it is little used except in spring, or grown for Northern shipment as an early crop. The crop was a heavy one in 1884, and has since been declining to quite

moderate production, the last crop yielding only 73 bushels per acre and a product of about 163,000,000 bushels. The yield was good in the Eastern States, medium in New York, and still less in Michigan and other Western States. The previous record is as follows:

Calendar years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value of yield per acre.
	Bushels.	*Acres.*	*Dollars.*	*Cents.*	*Bushels.*	*Dollars.*
1880	167,659,570	1,842,510	81,062,214	48.3	91.0	$44 00
1881	109,145,494	2,041,670	99,291,341	90.9	53.5	48 63
1882	170,972,508	2,171,636	95,304,844	55.7	78.7	43 89
1883	208,164,425	2,289,275	87,849,991	42.2	91.0	38 37
1884	190,642,000	2,220,980	75,524,290	39.6	85.8	34 00
1885	175,029,000	2,265,823	78,153,403	44.7	77.2	34 49
Total	1,021,612,997	12,831,894	517,186,083			
Annual average	170,268,833	2,138,649	86,197,681	50.6	79.6	40.30
Annual average for preceding ten years	132,837,175	1,514,045	74,653,771	56.2	87.7	49.31

Sweet-potatoes (*Batatas edulis*) are grown in the cotton States, and in a very limited way in others up to about the 40th degree of latitude. The product is increasing in the South with advancement of population. The area devoted to this crop in 1886 was largely increased in those States where it is a material part of the agricultural production, and condition on July 1 was high. The wet weather in the South during that month was not conducive to good growth, and there was a slight falling in the average of the larger States. This decline was continuing and more marked during August, and the figures of condition of September 1 gave evidence of local injuries from supersaturation in some sections and drought in others. The October condition in the principal States was: North Carolina, 93; Georgia, 90; Alabama, 92; Mississippi, 92; Tennessee, 95, and South Carolina, 94.

The crop may therefore be considered an average one, and may have reached 40,000,000 bushels. It slightly exceeded 33,000,000 bushels in 1879. North Carolina and Georgia are States of largest production, producing each about 5,000,000 bushels.

HAY.

The crop of 1886 was fully as large as that of 1885, but less than the two large crops of 1883 and 1884—about 45,000,000 tons—yielding about an average crop, or nearly one and one-fifth tons per acre. The crop is an important one, and it is gratifying to state that increasing attention is paid to it in the South, in connection with improved stock-growing and dairying. The use of Japan clover (*Lespedeza striata*) and several Southern grasses, and also of lucerne

(*Medicago sativa*) is increasing rapidly, with many striking and cheering results. The recent record of hay stands:

Calendar years.	Total production.	Total area of crop.	Total value of crop.	Average value per ton.	Average yield per acre.	Average value of yield per acre.
	Tons.	*Acres.*	*Dollars.*	*Dollars.*	*Tons.*	*Dollars.*
1880	31,925,233	25,863,955	371,811,084	11 65	1.23	14 38
1881	35,135,064	30,888,700	415,131,366	11 82	1.14	13 43
1882	38,138,049	32,339,585	369,958,158	9 70	1.18	11 44
1883	46,864,009	35,515,948	383,834,451	8 19	1.32	10 81
1884	48,470,460	38,571,593	396,139,309	8 17	1.26	10 27
1885	44,731,550	39,849,701	389,752,873	8 71	1.12	9 78
Total	245,264,365	203,029,482	2,326,627,241			
Annual average	40,877,394	33,838,247	387,771,207	9.49	1.21	11.46
Annual average for preceding ten years	28,526,750	23,142,841	323,935,991	11.36	1.23	14.00

TOBACCO.

The tobacco crop of 1886 was one of medium production, not yet fully determined as to quantity, but approaching nearly to 500,000,000 pounds, and furnishing a supply equal to the wants of consumption and exportation. The rate of yield is not far from an average of 700 pounds per acre. The previous record reads:

Calendar years.	Total production.	Total area of crop.	Total value of crop.	Average value per pound.	Average yield per acre.	Average value of yield per acre.
	Pounds.	*Acres.*	*Dollars.*	*Cents.*	*Pounds.*	*Dollars.*
1880	460,000,000	610,000	39,100,000	8.5	754.1	64 10
1881	450,880,014	646,239	43,372,000	9.6	697.7	67 11
1882	513,077,558	671,522	43,189,951	8.4	764.1	64 32
1883	451,545,641	638,739	40,455,362	9.0	706.9	63 34
1884	541,504,000	724,668	44,160,151	8.2	747.2	60 94
1885	562,736,000	752,520	43,265,598	7.7	747.8	57 49
Total	2,979,743,213	4,043,688	253,543,062			
Annual average	496,623,869	673,948	42,257,177	8.5	736.9	62.70
Annual average for preceding ten years	464,920,000	629,944	39,770,600	8.6	738.0	63.13

COTTON.

The area of cotton increased rapidly till 1860, when the acreage was probably about 12,000,000 acres. From 1861 to 1865 very little cotton was grown. The breadth in 1870 was not far from 7,000,000 acres. Extension has since been constant though unequal, and there is now in cultivation 50 per cent. more than in 1860.

Comparing production since 1865 with that of twenty years prior to 1861, the annual crop has increased more than 50 per cent. Seven-tenths of all was exported in the former period; in the latter, notwithstanding the enlargement of the product, less than two-thirds.

The season of 1886 was not a very favorable one for large production, especially that of planting and cultivation. The fine autumn did much to make amends for the misfortunes of the spring and

summer. Indications point to a crop a very little smaller than that of 1885, between six and a third and six and a half million bales.

After the excessive rains of the early season, which wrought serious injury and threatened still more, came the exceptional weather of the autumn, which prevented discoloration or stains, and favored picking with a minimum amount of dirt or trash, and ripened fully the well-developed bolls. The unfavorable season of germination and cultivation and the highly encouraging period of ripening and harvesting were antagonistic elements in the production of the crop, which have naturally caused much difference of opinion among crop experts as to the magnitude of the harvest. The first caused a failure of growth, a shedding of foliage and fruitage, a weakening of plant vitality, which inevitably caused a reduction of the crop. But there were areas in soil of strength and depth, well cultivated, where the plants remained thrifty and vigorous, in either fair or fine condition to produce a heavy yield under the favorable influences of the later season. The views and estimates of the harvest period were therefore naturally and properly more cheerful than those of the commencement of picking. As the larger average and comparatively higher condition are mainly in the districts of richer lands and larger capacity for production, these favorable autumn influences have been all the more potent, tending to enlarge the crop aggregate.

The close of picking is reported the same as last year in the Carolinas and Texas, one day earlier in Mississippi, two in Georgia, and two later in Louisiana, four in Tennessee, and twenty-one in Arkansas. The dates are: North Carolina, December 2; South Carolina, November 30; Georgia, December 1; Florida, November 27; Alabama, December 2; Mississippi, December 7; Louisiana, December 12; Texas, December 3; Arkansas, December 25; Tennessee, December 14. The late maturing of the crop extended the season slightly in a few States. Only in Arkansas was the season lengthened by inability to pick the heavy harvest earlier.

The average date of picking for the entire cotton belt was about two and a half days later than the previous year, as that was nine days later than the season of 1884. The record of four years is as follows:

States.	1886.	1885.	1884.	1883.
Virginia	Jan. 2	Dec. 11	Dec. 6	Dec. 12
North Carolina	Dec. 2	Dec. 2	Nov. 25	Nov. 28
South Carolina	Nov. 30	Nov. 30	Nov. 20	Nov. 23
Georgia	Dec. 1	Dec. 3	Nov. 19	Nov. 20
Florida	Nov. 27	Nov. 25	Nov. 30	Nov. 30
Alabama	Dec. 2	Nov. 28	Nov. 24	Nov. 24
Mississippi	Dec. 7	Dec. 8	Nov. 23	Nov. 26
Louisiana	Dec. 12	Dec. 10	Nov. 28	Nov. 23
Texas	Dec. 3	Dec. 3	Nov. 20	Nov. 30
Arkansas	Dec. 25	Dec. 4	Dec. 4	Dec. 12
Tennessee	Dec. 14	Dec. 10	Nov. 30	Dec. 10

The returns of proportion marketed make the average to February 1, 85.1 per cent. This would indicate a crop of about 6,460,000 bales, a mere trifle above the November indications of rate of yield. The proportions by States are as follows: North Carolina, 87; South Carolina, 88; Georgia, 85; Florida, 83; Alabama, 87; Mississippi, 84; Louisiana, 83; Texas, 86; Arkansas, 81; Tennessee, 83. The proportion reported February, 1886, was 83 per cent. of the crop of 1885.

The quality of the crop is superior. Rarely if ever have the returns of cleanness and color, combined with length of staple, equaled those just received. Last year the State averages were 7 to 10 points short of the standard of good quality in all of the Atlantic coast States except Florida and in Alabama, and nearly as much in Mississippi. In the other States it was near the normal standard.

The price of seed is low. Complaint is made of combinations of oil-millers to reduce prices. Renters will sell at any price, sometimes as low as 5 to 8 cents per bushel. The best planters refuse to sell at ruling rates. The average in Mississippi and Louisiana is 10 cents, 11 in Arkansas, 12 in Texas and Tennessee, 13 in South Carolina, Georgia, and Alabama, 16 in Florida. Feeders of cattle and sheep pay the highest rates.

If every planter would grind into meal his surplus seed and feed it to fattening stock on the premises he would derive a handsome return in meat, and have more and better stores of fertilizers than though he used the entire supply in the usual mode of applying to the soil. It is important that the seed should be returned to the soil; even if sold to mills, the refuse, after extraction of the oil, should be returned, or an equivalent for it procured from other sources. A combination to reduce prices of seed can easily be met by counter-combination of planters to sell only at its equivalent value for feeding and fertilizing. A single planter, without concert with his neighbor, will increase his personal gains by individual refusal to sell at 10 or 12 cents per bushel, feeding for meat instead, or even applying to the furrow direct from the gin-house. It is a monopoly, therefore, that should easily be circumvented, with or without concert of action, at least by all intelligent cotton-growers; and returns indicate that they have already measurably applied this remedy.

The return of lint to seed is generally higher than last year. The following table arranges the statistics here indicated:

States.	Lint.	Quality.	Proportion marketed.	Price of seed per bushel.
	Per cent.	*Per cent.*	*Per cent.*	*Cents.*
Virginia	31.5	98	82	32
North Carolina	31.5	101	87	14
South Carolina	32.0	100	83	13
Georgia	32.0	100	85	13
Florida	32.5	100	83	16
Alabama	31.5	100	87	13
Mississippi	31.5	99	84	10
Louisiana	31.5	100	83	10
Texas	32.0	98	86	12
Arkansas	32.0	100	81	11
Tennessee	32.0	100	83	12

LAST YEAR'S COTTON CROP.

The National Cotton Exchange made the record of the cotton movement of the product of 1885 6,575,691 bales. The Financial Chronicle record aggregates 6,550,215 bales of 485.40 pounds each, against 5,669,021 bales of 481.21 pounds; or, in pounds, 3,179,456,091 and 2,727,967,317 pounds, respectively, showing an increase of 451,488,774 pounds, or 16.55 per cent., over the crop grown in 1884. In actual bales the increase by this record is 881,194, and in bales of the same size as those of 1884, 938,236. The crop of 1886 will prove to be nearly as large.

It is a noteworthy fact, and a cheering indication to growers of the world's supply of cotton, that an increase of more than 16 per cent. has caused a decline in export value (according to the record of exports for the year ended June 30) of less than 7 per cent. Had the present crop been sold at the price paid for the previous one, the growers would have received scarcely twenty million dollars more.

The cotton movement, if assumed to be without error (and the two statements differ by 25,000 bales last year and 37,000 the year before), does not necessarily represent exactly the product grown in a given year, but does so substantially, and affords the best available test of the accuracy of our crop returns. What is the result of this test?

Stated briefly, the last four crops since the return of the present Statistician to his work have been indicated, with one exception, with nearly as much precision as by the ultimate record of the movement itself, the discrepancies being a fraction of one per cent. No non-official estimates have approached the departmental results in degree and uniformity of accuracy, and some of them have made annual discrepancies of a fourth to half a million bales.

In 1882 the October condition was 88, indicating 10 per cent. more than an average product, and, compared with 66 for the previous year, "would indicate nearly 7,000,000 bales." In November the returns of yield per acre indicated more than 3,000,000,000 pounds of net lint, but this was not given as the full estimate of the year's production. In the final report the local estimates footed up 6,835,000 bales, which was assumed to be slightly underestimated, the Statistician adding: "Should these returns of product prove conservative as usual, the movement would not be less than 7,000,000 bales." The National Cotton Exchange made its ultimate record of the movement 6,949,756 bales, and the Financial Chronicle 6,992,234 bales.

In October, 1883, it was said: "Indications point to a crop a little larger than that of 1881 (which was 5,456,048), but falling short of last crop by more than 1,000,000 bales." The local estimates of yield per acre pointed to a reduction of 14 to 15 per cent. The returns gave expectation of about 6,000,000 bales, but the final report in February indicated a crop somewhat less than 6,000,000 bales, or from 84 to 86 per cent. of the previous crop. This was 2 or 3 per cent. too high, as the movement was 5,713,200 bales, between 82 and 83 per cent. of the previous crop. This is the only season of recent years in which the discrepancy was as much as 1 per cent.

The crop of 1884, in October, was reported in lower condition than in September by 8 points, and the prospect of a top crop, as reported, was "reduced to a minimum," though the county estimates averaged 0.36 of a bale per acre. The final report indicated a smaller yield than the returns of condition in October, and the aggregate of local estimates was 5,646,441 bales, and the Statistician summed up the expectation from all these returns of "a crop of about 5,667,000 bales." The Financial Chronicle record was 5,669,021 bales, and that of the National Cotton Exchange 5,706,165 bales.

In October of 1885 the prospect was more favorable than in November and December. The county estimates of yield per acre, when consolidated, made an average of 36.75 of a bale per acre, which would forecast a crop of nearly 6,667,000 bales. The returns of condition the same month were equally favorable, indicating an increase of 1,000,000 bales in round numbers, "subject to future meteorological conditions," and not to be considered a final estimate, "as the date

of killing frost and the autumn weather may easily cause a variation of a quarter of a million bales."

In November it was reported that "the top crop is very light, and in many places scarcely an appreciable quantity." These returns were local estimates of yield per acre in pounds, which were somewhat lower, looking to a yield of about 6,500,000 bales. The final report summed up the crop prospects in these words: "The indications point to a crop approximating the November estimates of yield per acre, which looked to a product slightly exceeding 6,500,000 bales."

The recorded movement stands: By the Financial Chronicle, 6,550,215 bales; by the National Cotton Exchange, 6,575,691 bales.

Thus the crop of 1885 was foreshadowed as fairly and almost as fully as it could have been if the result had been published a year in advance of the completion of the actual count of bales.

It is 57 per cent. of the cotton product of the world, though American cotton planting is an industrial growth of less than a hundred years, while India, the original source of commercial cotton, produces only a third as much.

CROP ESTIMATES FOR 1885.

It should be understood that the following table does not include all the crops of each State, and that no comparison of the agricultural prominence of States can be fairly made from it. The only comparison that is practicable must relate to the specific crops named. Sugar and rice, fruits, market gardening, aud meats in the South, and flax, hemp, broom-corn, dairy products, and meats in the West, and many other products, some very local in distribution, in these and other sections of the country, are not included, simply because they are not estimated annually in sufficient detail. This explanation is made to prevent captious suggestions of unfairness to the different sections, which are absurd and unreasonable.

Table showing the product of the cereals, potatoes, tobacco, hay, and cotton of the several States named, the yield per acre, the total acreage, the average price in each State, and the value of each crop, for 1885.

States.	Products.	Quantity produced in 1885.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Maine	Indian corn ....bushels..	1,009,000	32.3	31,222	$0 70	$706,300
	Wheat ....do....	566,000	13.8	41,126	1 25	707,500
	Rye ....do....	29,000	12.2	2,385	84	24,327
	Oats ....do....	2,622,000	31.0	84,570	40	1,048,800
	Barley ....do....	276,000	22.4	12,302	69	190,140
	Buckwheat ....do....	371,000	17.5	21,185	54	200,199
	Potatoes ....do....	6,204,000	100.0	62,035	42	2,605,470
	Hay..............tons..	976,646	.85	1,148,995	11 95	11,670,920
	Total	....	....	1,403,820	....	17,153,656
New Hampshire...	Indian corn ....bushels..	1,299,000	33.8	38,386	71	922,290
	Wheat ....do....	174,000	15.4	11,267	1 24	215,760
	Rye ....do....	41,000	12.5	3,280	83	34,030
	Oats ....do....	1,092,000	34.7	31,506	42	458,640
	Barley ....do....	84,000	22.4	3,745	69	58,141
	Buckwheat........do....	95,000	20.1	4,737	54	51,160
	Potatoes ....do....	2,785,000	102.0	27,304	44	1,225,404
	Hay ....tons..	527,169	.80	658,961	12 75	6,721,405
	Total	....	....	779,186	....	9,686,830

Table showing the product of the cereals, potatoes, hay, and cotton, &c.—Continued.

States.	Products.	Quantity produced in 1885.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Vermont	Indian corn ....bushels..	1,979,000	32.2	61,488	$0 64	$1,266,560
	Wheat ....do....	390,000	17.7	22,007	1 11	432,900
	Rye ....do....	85,000	13.2	6,418	74	62,691
	Oats....do....	3,806,000	36.4	104,565	37	1,408,220
	Barley ....do....	295,000	25.2	11,711	70	206,582
	Buckwheat....do....	366,000	20.5	17,862	53	194,071
	Potatoes ....do....	3,656,000	98.0	37,304	35	1,279,527
	Hay ....tons....	902,700	.90	1,003,000	11 00	9,929,700
	Total	....	....	1,264,355	....	14,780,251
Massachusetts....	Indian corn ....bushels..	1,961,000	34.0	57,668	70	1,372,700
	Wheat ....do....	17,000	15.7	1,080	1 25	21,250
	Rye ....do....	275,000	11.3	24,294	81	222,363
	Oats....do....	753,000	31.0	24,267	43	323,790
	Barley ....do....	82,000	25.2	3,248	72	59,165
	Buckwheat....do....	59,000	11.1	5,334	55	32,271
	Potatoes ....do....	3,426,000	100.0	34,255	57	1,952,535
	Tobacco....pounds..	3,798,000	1,464.0	2,594	12	455,714
	Hay ....tons..	661,077	1.05	629,597	18 50	12,229,925
	Total	....	....	782,337	....	16,669,713
Rhode Island	Indian corn ....bushels..	429,000	33.5	12,818	72	308,880
	Rye ....do....	15,000	10.9	1,372	83	12,375
	Oats....do....	167,000	26.3	6,353	44	73,480
	Barley ....do....	19,000	24.0	791	72	13,756
	Buckwheat....do....	1,000	7.9	126	78	783
	Potatoes....do....	668,000	105.0	6,366	56	374,321
	Hay ....tons..	69,657	.80	87,071	18 30	1,274,723
	Total	....	....	114,897	....	2,058,318
Connecticut	Indian corn ....bushels..	2,033,000	35.0	58,140	63	1,280,790
	Wheat....do....	31,000	14.1	2,193	1 05	32,550
	Rye ....do....	382,000	13.0	29,393	75	286,582
	Oats....do....	1,090,000	28.5	38,262	42	457,800
	Barley....do....	14,000	22.2	632	74	10,381
	Buckwheat....do....	140,000	12.6	11,087	60	83,818
	Potatoes....do....	2,811,000	90.0	31,229	55	1,545,836
	Tobacco....pounds..	12,066,000	1,575.0	7,661	12.4	1,496,193
	Hay ....tons..	551,431	.95	580,454	18 00	9,925,758
	Total	....	....	759,051	....	15,119,708
New York....	Indian corn....bushels..	22,448,000	30.7	731,196	58	13,019,840
	Wheat....do....	10,565,000	15.4	687,367	96	10,142,400
	Rye ....do....	2,658,000	11.0	241,661	67	1,781,042
	Oats....do....	38,676,000	27.9	1,385,245	36	13,923,360
	Barley ....do....	7,478,000	22.0	339,922	71	5,309,582
	Buckwheat....do....	4,609,000	14.8	311,434	53	2,442,888
	Potatoes....do....	19,996,000	56.0	357,075	45	8,998,290
	Tobacco....pounds..	10,234,000	1,520.0	6,733	10	1,023,416
	Hay ....tons..	5,210,266	1.05	4,962,158	12 75	66,430,892
	Total	....	....	9,022,791	....	123,071,710
New Jersey....	Indian corn....bushels..	11,212,000	32.0	350,370	53	5,942,360
	Wheat.... do....	1,395,000	9.7	143,097	95	1,325,250
	Rye ....do....	1,140,000	10.8	105,588	65	741,228
	Oats....do....	3,556,000	26.6	133,451	37	1,315,720
	Barley....do....	5,000	19.5	257	75	3,752
	Buckwheat....do....	478,000	13.5	35,376	60	286,546
	Potatoes ....do....	3,069,000	75.0	40,916	54	1,657,098
	Hay....tons..	493,279	.95	519,241	16 50	8,139,104
	Total	....	....	1,328,296	....	19,411,058

Table showing the product of the cereals, potatoes, hay, and cotton, &c.—Continued.

States.	Products.	Quantity produced in 1885.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Pennsylvania	Indian corn ....bushels..	46,074,000	32.5	1,417,030	$0 49	$22,576,260
	Wheat.............do....	13,325,000	9.7	1,380,294	96	12,792,000
	Rye ....do....	3,298,000	8.2	402,179	66	2,176,593
	Oats..............do....	34,326,000	26.3	1,304,023	36	12,357,360
	Barley ....do....	485,000	18.5	26,194	70	339,212
	Buckwheat.........do....	3,897,000	14.2	274,415	54	2,104,441
	Potatoes ....do....	13,700,000	72.0	190,280	47	6,439,075
	Tobacco........pounds..	23,392,000	1,000.0	23,392	10.5	2,456,160
	Hay ....tons..	2,738,572	1.0	2,738,572	13 50	36,970,722
	Total	....	....	7,756,409	....	98,211,826
Delaware	Indian corn....bushels..	4,174,000	19.3	216,595	40	1,669,600
	Wheat ....do....	957,000	10.7	89,103	95	909,150
	Rye ....do....	6,000	7.0	857	75	4,500
	Oats..............do....	501,000	23.6	21,197	38	190,380
	Buckwheat.........do....	5,000	11.4	437	55	2,732
	Potatoes ....do....	315,000	76.0	4,141	50	157,358
	Hay ....tons..	44,665	.90	49,628	14 50	647,643
	Total	....	....	381,958	....	3,581,363
Maryland	Indian corn ....bushels..	15,999,000	22.0	726,336	46	7,359,540
	Wheat ....do....	5,534,000	9.5	580,482	91	5,035,940
	Rye ....do....	240,000	7.8	30,759	65	155,948
	Oats..............do....	2,475,000	22.3	111,100	35	866,250
	Barley ....do....	6,000	21.7	277	68	4,083
	Buckwheat.........do....	144,000	13.0	11,106	60	86,627
	Potatoes ....do....	1,528,000	75.0	20,378	49	748,892
	Tobacco........pounds..	28,552,000	663.0	43,065	7.3	2,084,303
	Hay ....tons..	272,037	.95	286,355	13 75	3,740,509
	Total	....	....	1,809,858	....	20,082,092
Virginia	Indian corn....bushels..	31,838,000	14.9	2,132,230	47	14,963,860
	Wheat.............do....	2,833,000	4.4	651,140	93	2,634,690
	Rye ....do....	323,000	6.7	48,216	67	216,441
	Oats..............do....	8,664,000	13.9	621,230	41	3,552,240
	Barley ....do....	20,000	17.0	1,175	65	12,984
	Buckwheat.........do....	187,000	9.0	20,734	61	113,830
	Potatoes ....do....	2,102,000	60.0	35,037	51	1,072,132
	Tobacco........pounds..	107,711,000	655.0	164,445	7.4	7,970,649
	Hay ....tons..	251,541	.85	295,930	13 28	3,340,461
	Cotton...........bales..	14,821	.33	44,913	* 8.5	579,501
	Total	....	....	4,015,050	....	34,456,791
North Carolina	Indian corn ....bushels..	25,199,000	9.9	2,545,126	55	13,859,450
	Wheat ....do....	2,790,000	4.1	682,888	1 00	2,790,000
	Rye ....do....	273,000	4.2	64,895	85	231,675
	Oats ....do....	4,483,000	7.5	599,117	50	2,241,500
	Barley ....do....	3,000	10.9	276	1 10	3,312
	Buckwheat.........do....	52,000	8.4	6,156	65	34,012
	Potatoes ....do....	1,256,000	61.0	20,597	57	716,158
	Tobacco...........do....	37,417,000	480.0	77,952	10.6	3,966,198
	Hay...........pounds..	96,680	.95	101,768	11 68	1,129,222
	Cotton ....bales..	407,230	.38	1,071,658	*8.5	15,922,693
	Total	....	....	5,170,433	....	40,894,220
South Carolina	Indian corn ....bushels..	13,453,000	9.0	1,487,341	56	7,533,680
	Wheat ....do....	1,170,000	5.3	220,030	1 10	1,287,000
	Rye ....do....	32,000	4.0	8,036	1 00	32,144
	Oats ....do....	3,510,000	8.5	413,963	54	1,895,400
	Barley ....do....	16,000	12.9	1,236	1 10	17,675
	Potatoes ....do....	235,000	60.0	3,911	75	175,995
	Hay..............tons..	4,336	1.0	4,336	13 75	59,620
	Cotton ....bales..	554,652	.32	1,733,289	*8.5	21,969,766
	Total	....	....	3,872,142	....	32,971,280

* Per pound.

Table showing the product of the cereals, potatoes, hay, and cotton, &c.—Continued.

States.	Products.	Quantity produced in 1885.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Georgia	Indian corn ....bushels..	32,162,000	11.3	2,857,700	$0 58	$18,653,960
	Wheat ....do....	2,817,000	6.2	453,375	1 09	3,070,530
	Rye ....do....	121,000	4.5	26,814	1 13	136,349
	Oats ....do....	6,395,000	9.0	709,640	53	3,389,350
	Barley ....do....	24,000	14.1	1,699	1 09	26,143
	Potatoes ....do....	578,000	63.0	9,175	94	543,344
	Hay..............tons..	16,642	1.0	16,642	13 84	230,325
	Cotton ....bales..	960,025	.315	3,047,698	*8.5	39,413,826
	Total	....	....	7,122,743	....	65,463,827
Florida	Indian corn ....bushels..	3,799,000	9.0	420,070	70	2,659,300
	Oats ....do....	519,000	9.7	53,611	67	347,730
	Potatoes ....do....	155,000	80.0	1,938	1 00	155,040
	Hay............. tons..	370	.70	528	18 00	6,660
	Cotton ....bales..	73,837	.27	273,473	*13.0	4,357,860
	Total	....	....	749,620	....	7,526,590
Alabama	Indian corn ....bushels..	31,405,000	13.4	2,346,114	55	17,272,750
	Wheat ....do....	1,307,000	5.5	239,437	1 03	1,346,210
	Rye ....do....	28,000	4.7	5,938	1 10	30,700
	Oats ....do....	4,915,000	12.2	401,772	54	2,654,100
	Potatoes ....do....	617,000	66.0	9,353	97	598,779
	Hay..............tons..	13,298	.94	14,147	12 73	169,284
	Cotton ....bales..	760,447	.272	2,795,760	*8.5	31,349,428
	Total	....	....	5,812,551	....	53,421,251
Mississippi	Indian corn ....bushels..	25,765,000	13.4	1,927,392	54	13,913,100
	Wheat ....do....	190,000	4.9	38,448	1 04	197,600
	Oats ....do....	3,962,000	11.2	355,001	55	2,179,100
	Potatoes ....do....	576,000	68.0	8,471	85	489,624
	Hay..............tons..	11,069	1.0	11,069	11 75	130,061
	Cotton ....bales..	1,019,470	.402	2,535,994	*8.5	41,854,341
	Total	....	....	4,876,375	....	58,763,826
Louisiana	Indian corn ....bushels..	15,410,000	16.8	917,377	53	8,167,300
	Oats ....do....	420,000	11.4	36,875	47	197,400
	Potatoes ....do....	466,000	70.0	6,661	84	391,667
	Hay.... ....tons..	38,984	1.0	38,984	11 00	428,824
	Cotton ....bales..	487,722	.485	1,005,613	*8.5	20,106,339
	Total	....	....	2,005,510	....	29,291,530
Texas	Indian corn ....bushels..	84,406,000	20.6	4,090,443	49	41,358,940
	Wheat ....do....	6,117,000	11.2	545,468	80	4,893,600
	Rye ....do....	41,000	7.0	5,821	67	27,300
	Oats ....do....	14,211,000	27.8	512,006	37	5,258,070
	Barley ....do....	130,000	16.3	7,993	54	70,354
	Potatoes ....do....	651,000	68.0	9,579	90	586,235
	Hay..............tons..	83,899	.95	83,315	10 78	904,431
	Cotton ....bales..	1,332,027	.38	3,505,335	*8.2	54,613,107
	Total	....	....	8,764,960	....	107,712,037
Arkansas	Indian corn ....bushels..	38,309,000	20.2	1,898,327	46	17,622,140
	Wheat ....do....	1,565,000	6.5	240,997	1 00	1,565,000
	Rye ....do....	27,000	6.6	4,114	79	21,393
	Oats ....do....	5,313,000	21.1	251,284	45	2,390,850
	Potatoes ....do....	932,000	76.0	12,268	66	615,363
	Tobacco........pounds..	1,606,000	700.0	2,294	7	112,406
	Hay..............tons..	29,701	1.0	29,701	11 00	326,711
	Cotton ....bales..	610,666	.453	1,348,048	*8.5	25,226,612
	Total	....	....	3,787,033	....	47,880,475

* Per pound.

Table showing the product of the cereals, potatoes, hay, and cotton, &c.—Continued.

States.	Products.	Quantity produced in 1885.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Tennessee	Indian corn....bushels..	75,581,000	21.2	3,569,590	$0 39	$29,476,590
	Wheat............do....	3,821,000	3.2	1,175,882	95	3,629,950
	Rye..............do....	180,000	5.2	34,692	76	137,102
	Oats.............do....	10,752,000	17.3	620,096	34	3,655,680
	Barley...........do....	42,000	13.5	3,112	62	26,047
	Buckwheat........do....	60,000	10.3	5,833	66	39,653
	Potatoes.........do....	2,531,000	65.0	38,937	46	1,164,216
	Tobacco........pounds..	26,939,000	575.0	46,850	7	1,885,713
	Hay..............tons..	229,088	1.10	208,262	11 67	2,673,457
	Cotton..........bales..	321,638	.372	864,618	*8.5	13,259,527
	Total..............	....	....	6,567,872	....	55,947,935
West Virginia	Indian corn....bushels..	15,827,000	23.8	665,409	40	6,330,800
	Wheat............do....	1,493,000	5.6	268,961	1 01	1,507,930
	Rye..............do....	89,000	5.0	17,744	70	62,104
	Oats.............do....	2,831,000	20.5	138,039	35	990,850
	Barley...........do....	9,000	15.6	578	55	4,959
	Buckwheat........do....	413,000	10.5	39,331	61	251,915
	Potatoes.........do....	1,933,000	70.0	27,609	43	831,031
	Tobacco........pounds..	2,782,000	664.0	4,190	7.6	211,444
	Hay..............tons..	289,841	.82	353,465	11 41	3,307,086
	Total..............	....	....	1,515,326	....	13,498,119
Kentucky	Indian corn....bushels..	90,569,000	25.5	3,551,667	35	31,699,150
	Wheat............do....	3,759,000	3.6	1,055,760	95	3,571,050
	Rye..............do....	495,000	5.3	93,347	71	351,265
	Oats.............do....	10,225,000	20.8	491,545	33	3,374,250
	Barley...........do....	342,000	17.5	19,564	67	229,388
	Buckwheat........do....	11,000	9.5	1,152	67	7,419
	Potatoes.........do....	3,387,000	67.0	50,556	42	1,422,646
	Tobacco........pounds..	209,423,000	790.0	265,093	6.5	13,612,526
	Hay..............tons..	313,200	1.0	313,200	10 25	3,210,300
	Total..............	....	....	5,841,884	....	57,477,994
Ohio	Indian corn....bushels..	111,865,000	37.1	3,017,464	32	35,796,800
	Wheat............do....	20,593,000	10.2	2,018,952	91	18,739,630
	Rye..............do....	389,000	11.0	35,394	60	233,600
	Oats.............do....	37,470,000	37.3	1,003,680	27	10,116,900
	Barley...........do....	832,000	20.5	40,583	67	557,408
	Buckwheat........do....	182,000	14.0	12,995	65	118,255
	Potatoes.........do....	12,453,000	75.0	166,035	39	4,856,524
	Tobacco........pounds..	33,767,000	920.0	36,703	6.3	2,127,306
	Hay..............tons..	2,748,900	1.10	2,499,000	11 44	31,447,416
	Total..............	....	....	8,830,806	....	103,993,839
Michigan	Indian corn....bushels..	30,706,000	32.7	938,682	34	10,440,040
	Wheat............do....	31,261,000	19.3	1,623,929	84	26,259,240
	Rye..............do....	250,000	11.3	22,118	59	147,460
	Oats.............do....	21,789,000	35.4	615,800	28	6,100,920
	Barley...........do....	1,209,000	23.3	51,874	60	725,198
	Buckwheat........do....	433,000	12.8	33,826	58	251,124
	Potatoes.........do....	12,880,000	87.0	148,048	34	4,379,260
	Hay..............tons..	1,507,232	1.20	1,256,027	10 71	16,142,455
	Total..............	....	....	4,690,304	....	64,445,697
Indiana	Indian corn....bushels..	131,994,000	35.5	3,720,681	29	38,278,260
	Wheat............do....	26,659,000	10.6	2,518,455	86	22,926,740
	Rye..............do....	278,000	11.0	25,256	59	163,911
	Oats.............do....	27,178,000	26.8	1,014,630	25	6,794,500
	Barley...........do....	266,000	17.3	15,398	55	146,512
	Buckwheat........do....	89,000	10.2	8,737	65	57,926
	Potatoes.........do....	6,779,000	72.0	94,151	36	2,440,394
	Tobacco........pounds..	9,593,000	720.0	13,324	9	863,395
	Hay..............tons..	1,762,560	1.20	1,468,800	7 79	13,730,342
	Total..............	....	....	8,879,432	....	85,401,980

* Per pound.

Table showing the product of the cereals, potatoes, hay, and cotton, &c.—Continued.

States.	Products.	Quantity produced in 1885.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Illinois	Indian corn ....bushels..	268,998,000	31.4	8,559,036	$0 28	$75,319,440
	Wheat ....do....	10,683,000	8.5	1,255,905	81	8,653,230
	Rye ....do....	2,302,000	12.7	181,277	53	1,220,176
	Oats ....do....	107,968,000	32.8	3,290,081	24	25,912,320
	Barley ....do....	1,001,000	24.2	41,361	57	570,534
	Buckwheat ....do....	194,000	12.5	15,491	64	123,928
	Potatoes ....do....	12,371,000	87.0	142,198	42	5,195,915
	Tobacco ....pounds..	4,963,000	840.0	5,908	9	446,645
	Hay..............tons..	4,298,125	1.30	3,306,250	7 35	31,591,219
	Total	....	....	16,797,507	....	149,033,407
Wisconsin	Indian corn ....bushels..	32,750,000	30.1	1,088,019	34	11,135,000
	Wheat ....do....	15,665,000	11.5	1,362,785	76	11,905,400
	Rye ....do....	2,167,000	12.3	176,162	52	1,126,732
	Oats ....do....	47,778,000	33.8	1,412,474	26	12,422,280
	Barley ....do....	9,302,000	22.4	415,285	47	4,372,120
	Buckwheat ....do....	375,000	10.0	37,473	69	258,564
	Potatoes ....do....	8,955,000	83.0	107,895	47	4,208,984
	Tobacco ....pounds..	31,196,000	1,150.0	27,127	9.5	2,963,625
	Hay..............tons..	1,850,228	1.10	1,682,025	7 00	12,951,596
	Total	....	....	6,309,245	....	61,344,301
Minnesota	Indian corn ....bushels..	18,431,000	28.4	648,913	32	5,897,920
	Wheat ....do....	34,285,000	11.1	3,084,274	70	23,999,500
	Rye ....do....	500,000	15.3	32,710	48	240,222
	Oats ....do....	37,544,000	34.9	1,076,393	25	9,386,000
	Barley ....do....	8,033,000	23.8	337,525	41	3,293,569
	Buckwheat ....do....	73,000	11.2	6,539	70	51,266
	Potatoes ....do....	5,263,000	85.0	61,923	40	2,105,382
	Hay..............tons..	2,457,000	1.20	2,047,500	4 65	11,425,050
	Total	....	....	7,295,777	....	56,398,909
Iowa	Indian corn ....bushels..	242,496,000	32.1	7,549,542	24	58,199,040
	Wheat ....do....	30,332,000	11.3	2,683,944	67	20,322,440
	Rye ....do....	1,746,000	13.7	127,459	46	803,246
	Oats ....do....	74,718,000	33.8	2,210,338	22	16,437,960
	Barley ....do....	5,106,000	23.0	221,999	39	1,991,331
	Buckwheat ....do....	244,000	11.8	20,679	68	165,928
	Potatoes ....do....	12,381,000	90.0	137,563	41	5,076,075
	Hay..............tons..	4,355,625	1.15	3,787,500	4 85	21,124,781
	Total	....	....	16,739,024	....	124,120,801
Missouri	Indian corn ....bushels..	196,861,000	31.3	6,295,728	25	49,215,250
	Wheat ....do....	11,275,000	7.4	1,517,598	77	8,681,750
	Rye ....do....	505,000	10.4	48,552	56	282,767
	Oats ....do....	28,312,000	22.3	1,267,849	26	7,361,120
	Barley ....do....	156,000	22.3	7,006	52	81,242
	Buckwheat........do....	61,000	10.3	5,894	68	41,281
	Potatoes ....do....	6,653,000	85.0	78,275	39	2,594,816
	Tobacco........pounds..	14,514,000	880.0	16,493	7	1,015,969
	Hay ....tons..	1,575,000	1.20	1,312,500	7 25	11,418,750
	Total	....	....	10,549,895	....	80,692,945
Kansas	Indian corn ....bushels..	158,390,000	32.4	4,884,550	24	38,013,600
	Wheat ....do....	11,197,000	10.6	1,060,250	65	7,278,050
	Rye ....do....	2,383,000	11.6	205,461	40	953,339
	Oats ....do....	27,145,000	31.8	853,920	23	6,243,350
	Barley ....do....	877,000	20.8	42,145	34	298,049
	Buckwheat........do....	24,000	12.7	1,889	62	14,876
	Potatoes ....do....	7,011,000	80.0	87,638	52	3,645,741
	Hay ....tons..	3,800,000	1.25	3,040,000	4 25	16,150,000
	Total	....	....	10,175,853	....	72,597,005

Table showing the product of the cereals, potatoes, hay, and cotton, &c.—Continued.

States.	Products.	Quantity produced in 1885.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Nebraska	Indian corn ....bushels..	129,426,000	36.7	3,526,475	$0 19	$24,590,940
	Wheat ....do....	19,828,000	11.3	1,755,252	57	11,301,960
	Rye ....do....	923,000	13.3	69,407	33	304,627
	Oats ....do....	24,028,000	34.3	700,048	19	4,565,320
	Barley ....do....	3,862,000	21.8	177,150	33	1,274,417
	Buckwheat........do....	28,000	12.5	2,237	66	18,467
	Potatoes ....do....	3,951,000	81.0	48,777	36	1,422,337
	Hay ....tons..	2,593,175	1.30	1,994,750	3 51	9,102,044
	Total	....	....	8,274,096	....	52,580,112
California	Indian corn ....bushels..	3,840,000	24.7	155,300	68	2,611,200
	Wheat ....do....	26,592,000	9.4	2,822,400	67	17,816,640
	Rye ....do....	310,000	10.3	30,105	76	235,662
	Oats ....do....	2,106,000	27.0	78,008	48	1,010,880
	Barley ....do....	12,703,000	18.1	701,809	79	10,035,167
	Buckwheat........do....	25,000	20.1	1,243	68	16,905
	Potatoes ....do....	4,887,000	85.0	57,491	63	3,078,643
	Hay ....tons..	1,127,160	1.20	939,300	11 50	12,962,340
	Total	....	....	4,785,556	....	47,767,437
Oregon	Indian corn ....bushels..	148,000	22.8	6,479	70	103,600
	Wheat ....do....	13,916,000	15.9	876,102	69	9,602,040
	Rye ....do....	20,000	14.9	1,338	75	15,053
	Oats ....do....	5,798,000	30.0	193,397	37	2,145,260
	Barley ....do....	704,000	20.2	34,845	49	344,896
	Buckwheat........do....	6,000	10.7	561	62	3,703
	Potatoes ....do....	1,322,000	105.0	12,587	36	475,789
	Hay ....tons..	446,250	1.25	357,000	8 65	3,860,063
	Total	....	....	1,482,309	....	16,550,404
Nevada	Indian corn ....bushels..	21,000	24.8	847	75	15,750
	Wheat ....do....	103,000	18.5	5,570	92	94,760
	Oats ....do....	271,000	34.5	7,858	47	127,370
	Barley ....do....	465,000	20.0	23,272	81	377,006
	Potatoes ....do....	355,000	75.0	4,733	65	230,734
	Hay ....tons..	135,000	.90	150,000	7 25	978,750
	Total	....	....	192,280	....	1,824,370
Colorado	Indian corn ....bushels..	959,000	34.5	27,830	68	652,120
	Wheat ....do....	2,395,000	19.8	120,943	82	1,963,900
	Rye ....do....	35,000	17.8	1,966	68	23,710
	Oats ....do....	1,698,000	37.3	45,478	46	781,080
	Barley ....do....	156,000	24.0	6,494	60	93,514
	Potatoes ....do....	747,000	95.0	7,860	61	455,487
	Hay ....tons..	87,600	1.0	87,600	9 90	867,240
	Total	....	....	298,171	....	4,837,051
Arizona...........	Indian corn ....bushels..	66,000	22.1	2,993	75	49,500
	Wheat ....do....	303,000	14.0	21,578	95	287,850
	Barley ....do....	447,000	20.0	22,362	80	357,792
	Potatoes ....do....	84,000	70.0	1,204	69	58,153
	Hay ....tons..	22,950	.90	25,500	13 00	298,350
	Total	....	....	73,637	....	1,051,645
Dakota	Indian corn ....bushels..	15,345,000	28.9	530,100	28	4,296,600
	Wheat ....do....	27,913,000	12.8	2,187,084	63	17,585,190
	Rye ....do....	113,000	12.0	9,433	56	63,390
	Oats ....do....	13,229,000	37.5	352,800	23	3,042,670
	Barley ....do....	2,403,000	25.0	96,075	37	888,694
	Buckwheat........do....	4,000	8.1	495	69	2,772
	Potatoes ....do....	2,700,000	75.0	36,000	42	1,134,000
	Hay ....tons..	1,375,000	1.25	1,100,000	3 94	5,417,500
	Total	....	....	4,311,987	....	32,430,816

Table showing the product of the cereals, potatoes, hay, and cotton, &c.—Continued.

States.	Products.	Quantity produced in 1885.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Idaho	Indian corn ....bushels	41,000	21.5	1,911	$0 82	$33,620
	Wheat ....do	1,154,000	18.5	62,370	75	865,500
	Rye ....do	13,000	11.9	1,095	58	7,556
	Oats ....do	1,032,000	30.3	34,088	40	412,800
	Barley ....do	353,000	26.0	13,582	75	264,849
	Potatoes ....do	252,000	80.0	3,150	52	131,040
	Hay ....tons	144,383	1.15	125,550	10 50	1,516,022
	Total	....	....	241,746	....	3,231,387
Montana	Indian corn ....bushels	22,000	25.0	880	80	17,600
	Wheat ....do	1,715,000	20.4	83,864	77	1,320,550
	Oats ....do	1,775,000	33.1	53,560	42	745,500
	Barley ....do	71,000	30.2	2,353	77	54,354
	Potatoes ....do	262,000	82.0	3,198	50	131,118
	Hay ....tons	156,750	1.10	142,500	10 37	1,625,498
	Total	....	....	286,355	....	3,894,620
New Mexico	Indian corn....bushels	979,000	20.5	47,672	78	763,620
	Wheat ....do	1,023,000	14.0	73,242	1 02	1,043,460
	Oats ....do	282,000	20.4	13,841	40	112,800
	Barley ....do	63,000	19.4	3,240	84	53,152
	Potatoes ....do	35,000	70.0	501	32	11,222
	Hay ....tons	18,900	.90	21,000	14 50	274,050
	Total	....	....	159,496	....	2,258,304
Utah	Indian corn ....bushels	409,000	29.8	13,742	60	245,400
	Wheat ....do	1,926,000	19.9	96,861	61	1,174,860
	Rye ....do	22,000	9.5	2,310	51	11,192
	Oats ....do	845,000	30.5	27,687	36	304,200
	Barley ....do	288,000	22.0	13,098	52	149,841
	Potatoes ....do	863,000	90.0	9,591	36	310,748
	Hay ....tons	159,120	1.30	122,400	5 97	949,946
	Total	....	....	285,689	....	3,146,187
Washington	Indian corn ....bushels	89,000	26.4	3,371	71	63,190
	Wheat ....do	7,412,000	17.5	424,276	72	5,336,640
	Rye ....do	22,000	15.1	1,455	64	14,025
	Oats ....do	3,095,000	38.5	80,357	33	1,021,350
	Barley ....do	734,000	27.0	27,191	48	352,395
	Potatoes ....do	1,136,000	109.0	10,422	35	397,599
	Hay ....tons	190,944	1.20	159,120	7 14	1,363,340
	Total	....	....	706,192	....	8,548,539
Wyoming	Wheat ....do	66,000	20.8	3,180	80	52,800
	Oats ....do	84,000	32.0	2,625	44	36,960
	Potatoes ....do	112,000	93.0	1,208	60	67,406
	Hay ....tons	93,500	1.10	85,000	10 25	958,375
	Total	....	....	92,013	....	1,115,541

Summary for each State, showing the product, area, and value of each crop for 1885.

States and Territories.	Corn.			Wheat.		
	Bushels.	Acres.	Value.	Bushels.	Acres.	Value.
Maine	1,009,000	31,222	$706,300	566,000	41,126	$707,500
New Hampshire	1,299,000	38,386	922,290	174,000	11,267	215,760
Vermont	1,979,000	61,438	1,266,560	390,000	22,007	432,900
Massachusetts	1,961,000	57,668	1,372,700	17,000	1,080	21,250
Rhode Island	429,000	12,818	308,880	....	....	....
Connecticut	2,033,000	58,140	1,280,790	31,000	2,193	32,550
New York	22,448,000	731,196	13,019,840	10,565,000	687,367	10,142,400
New Jersey	11,212,000	350,370	5,942,360	1,395,000	143,097	1,325,250
Pennsylvania	46,074,000	1,417,030	22,576,260	13,325,000	1,380,294	12,792,000
Delaware	4,174,000	216,595	1,669,600	957,000	89,103	909,150
Maryland	15,999,000	726,336	7,359,540	5,534,000	580,482	5,035,940
Virginia	31,838,000	2,132,230	14,963,860	2,833,000	651,140	2,634,690
North Carolina	25,199,000	2,545,126	13,859,450	2,790,000	682,888	2,790,000
South Carolina	13,453,000	1,487,341	7,533,680	1,170,000	220,030	1,287,000
Georgia	32,162,000	2,857,700	18,653,960	2,817,000	453,375	3,070,530
Florida	3,799,000	420,070	2,659,300	....	....	....
Alabama	31,405,000	2,346,114	17,272,750	1,307,000	239,467	1,346,210
Mississippi	25,765,000	1,927,392	13,913,100	190,000	38,448	197,600
Louisiana	15,410,000	917,377	8,167,300	....	....	....
Texas	84,406,000	4,090,443	41,358,940	6,117,000	545,468	4,893,600
Arkansas	38,309,000	1,898,327	17,622,140	1,565,000	240,997	1,565,000
Tennessee	75,581,000	3,569,590	29,476,590	3,821,000	1,175,882	3,629,950
West Virginia	15,827,000	665,409	6,330,800	1,493,000	268,961	1,507,930
Kentucky	90,569,000	3,551,667	31,699,150	3,759,000	1,055,760	3,571,050
Ohio	111,865,000	3,017,464	35,796,800	20,593,000	2,018,952	18,739,630
Michigan	30,706,000	938,682	10,440,040	31,261,000	1,623,929	26,259,240
Indiana	131,994,000	3,720,681	38,278,260	26,659,000	2,518,455	22,926,740
Illinois	268,998,000	8,559,036	75,319,440	10,683,000	1,255,905	8,653,230
Wisconsin	32,750,000	1,088,019	11,135,000	15,665,000	1,362,785	11,905,400
Minnesota	18,431,000	648,913	5,897,920	34,285,000	3,084,274	23,999,500
Iowa	242,496,000	7,549,542	58,199,040	30,332,000	2,683,944	20,322,440
Missouri	196,861,000	6,295,728	49,215,250	11,275,000	1,517,598	8,681,750
Kansas	158,390,000	4,884,550	38,013,600	11,197,000	1,060,250	7,278,050
Nebraska	129,426,000	3,526,475	24,590,940	19,828,000	1,755,252	11,301,960
California	3,840,000	155,200	2,611,200	26,592,000	2,822,400	17,816,640
Oregon	148,000	6,479	103,600	13,916,000	876,102	9,602,040
Nevada	21,000	847	15,750	103,000	5,570	94,760
Colorado	959,000	27,830	652,120	2,395,000	120,943	1,963,900
Arizona	66,000	2,993	49,500	303,000	21,578	287,850
Dakota	15,345,000	530,100	4,296,600	27,913,000	2,187,084	17,585,190
Idaho	41,000	1,911	33,620	1,154,000	62,370	865,500
Montana	22,000	880	17,600	1,715,000	83,864	1,320,550
New Mexico	979,000	47,672	763,620	1,023,000	73,242	1,043,460
Utah	409,000	13,742	245,400	1,926,000	96,861	1,174,860
Washington	89,000	3,371	63,190	7,412,000	424,276	5,336,640
Wyoming	....	....	....	66,000	3,180	52,800
Total	1,936,176,000	73,130,150	635,674,630	357,112,000	34,189,246	275,320,390

States and Territories.	Rye.			Oats.		
	Bushels.	Acres.	Value.	Bushels.	Acres.	Value.
Maine	29,000	2,385	$24,327	2,622,000	84,570	$1,048,800
New Hampshire	41,000	3,280	34,030	1,092,000	31,506	458,640
Vermont	85,000	6,418	62,691	3,806,000	104,565	1,408,220
Massachusetts	275,000	24,294	222,363	753,000	24,267	323,790
Rhode Island	15,000	1,372	12,375	167,000	6,353	73,480
Connecticut	382,000	29,393	286,582	1,090,000	38,262	457,800
New York	2,658,000	241,661	1,781,042	38,676,000	1,385,245	13,923,360
New Jersey	1,140,000	105,588	741,228	3,556,000	133,451	1,315,720
Pennsylvania	3,298,000	402,179	2,176,593	34,326,000	1,304,023	12,357,360
Delaware	6,000	857	4,500	501,000	21,197	190,380
Maryland	240,000	30,759	155,948	2,475,000	111,100	866,250
Virginia	323,000	48,216	216,441	8,664,000	621,230	3,552,240
North Carolina	273,000	64,895	231,675	4,483,000	599,117	2,241,500
South Carolina	32,000	8,036	32,144	3,510,000	413,963	1,895,400
Georgia	121,000	26,814	136,349	6,395,000	709,640	3,389,350
Florida	....	....	....	519,000	53,611	347,730
Alabama	28,000	5,938	30,700	4,915,000	401,772	2,654,100
Mississippi	....	....	....	3,962,000	355,001	2,179,100
Louisiana	....	....	....	420,000	36,875	197,400
Texas	41,000	5,821	27,300	14,211,000	512,006	5,258,070
Arkansas	27,000	4,114	21,393	5,313,000	251,284	2,390,850
Tennessee	180,000	34,692	137,102	10,752,000	620,096	3,655,680

Summary for each State, showing the product, area, and value, &c.—Continued.

States and Territories.	Rye.			Oats.		
	Bushels.	Acres.	Value.	Bushels.	Acres.	Value.
West Virginia	89,000	17,744	$62,104	2,831,000	138,039	$990,850
Kentucky	495,000	93,347	351,265	10,225,000	491,545	3,374,250
Ohio	389,000	35,394	233,600	37,470,000	1,003,680	10,116,900
Michigan	250,000	22,118	147,460	21,789,000	615,800	6,100,920
Indiana	278,000	25,256	163,911	27,178,000	1,014,630	6,794,500
Illinois	2,302,000	181,277	1,220,176	107,968,000	3,290,081	25,912,320
Wisconsin	2,167,000	176,162	1,126,732	47,778,000	1,412,474	12,422,280
Minnesota	500,000	32,710	240,222	37,544,000	1,076,393	9,386,000
Iowa	1,746,000	127,459	803,246	74,718,000	2,210,338	16,437,960
Missouri	505,000	48,552	282,767	28,312,000	1,267,849	7,361,120
Kansas	2,383,000	205,461	953,339	27,145,000	853,920	6,243,350
Nebraska	923,000	69,407	304,627	24,028,000	700,048	4,565,320
California	310,000	30,105	235,662	2,106,000	78,008	1,010,880
Oregon	20,000	1,338	15,053	5,798,000	193,397	2,145,260
Nevada	....	....	....	271,000	7,858	127,370
Colorado	35,000	1,966	23,710	1,698,000	45,478	781,080
Dakota	113,000	9,433	63,390	13,229,000	352,800	3,042,670
Idaho	13,000	1,095	7,556	1,032,000	34,088	412,800
Montana	....	....	....	1,775,000	53,560	745,500
New Mexico	....	....	....	282,000	13,841	112,800
Utah	22,000	2,310	11,192	845,000	27,687	304,200
Washington	22,000	1,455	14,025	3,095,000	80,357	1,021,350
Wyoming	....	....	....	84,000	2,625	36,960
Total	21,756,000	2,129,301	12,594,820	629,409,000	22,783,630	179,631,860

States and Territories.	Barley.			Buckwheat.		
	Bushels.	Acres.	Value.	Bushels.	Acres.	Value.
Maine	276,000	12,302	$190,140	371,000	21,185	$200,199
New Hampshire	84,000	3,745	58,141	95,000	4,737	51,160
Vermont	295,000	11,711	206,582	366,000	17,862	194,071
Massachusetts	82,000	3,248	59,165	59,000	5,334	32,271
Rhode Island	19,000	791	13,756	1,000	126	783
Connecticut	14,000	632	10,381	140,000	11,087	83,818
New York	7,478,000	339,922	5,309,582	4,609,000	311,434	2,442,888
New Jersey	5,000	257	3,752	478,000	35,376	286,546
Pennsylvania	485,000	26,194	339,212	3,897,000	274,445	2,104,444
Delaware	....	....	....	5,000	437	2,732
Maryland	6,000	277	4,083	144,000	11,106	86,627
Virginia	20,000	1,175	12,984	187,000	20,734	113,830
North Carolina	3,000	276	3,312	52,000	6,156	34,012
South Carolina	16,000	1,236	17,675	....	....	....
Georgia	24,000	1,699	26,143	....	....	....
Texas	130,000	7,993	70,354	....	....	....
Tennessee	42,000	3,112	26,047	60,000	5,833	39,653
West Virginia	9,000	578	4,959	413,000	39,331	251,915
Kentucky	342,000	19,564	229,388	11,000	1,152	7,419
Ohio	832,000	40,583	557,408	182,000	12,995	118,255
Michigan	1,209,000	51,874	725,198	433,000	33,826	251,124
Indiana	266,000	15,398	146,512	89,000	8,737	57,926
Illinois	1,001,000	41,361	570,534	194,000	15,491	123,928
Wisconsin	9,302,000	415,285	4,372,120	375,000	37,473	258,564
Minnesota	8,033,000	337,525	3,293,569	73,000	6,539	51,266
Iowa	5,106,000	221,999	1,991,331	244,000	20,679	165,928
Missouri	156,000	7,006	81,242	61,000	5,894	41,281
Kansas	877,000	42,145	298,049	24,000	1,889	14,876
Nebraska	3,862,000	177,150	1,274,417	28,000	2,237	18,467
California	12,703,000	701,809	10,035,167	25,000	1,243	16,905
Oregon	704,000	34,845	344,896	6,000	561	3,703
Nevada	465,000	23,272	377,006	....	....	....
Colorado	156,000	6,494	93,514	....	....	....
Arizona	447,000	22,362	357,792	....	....	....
Dakota	2,402,000	96,075	888,694	4,000	495	2,772
Idaho	353,000	13,582	264,849	....	....	....
Montana	71,000	2,353	54,354	....	....	....
New Mexico	63,000	3,240	53,152	....	....	....
Utah	288,000	13,098	149,841	....	....	....
Washington	734,000	27,191	352,395	....	....	....
Total	58,360,000	2,729,359	32,867,696	12,626,000	914,394	7,057,363

Summary for each State, showing the product, area, and value, &c.—Continued.

States and Territories.	Potatoes.			Hay.		
	Bushels.	Acres.	Value.	Tons.	Acres.	Value.
Maine	6,204,000	62,035	$2,605,470	976,646	1,148,995	$11,670,920
New Hampshire	2,785,000	27,304	1,225,404	527,169	658,961	6,721,405
Vermont	3,656,000	37,304	1,279,527	902,700	1,003,000	9,929,700
Massachusetts	3,426,000	34,255	1,952,535	661,077	629,597	12,229,925
Rhode Island	668,000	6,366	374,321	69,657	87,071	1,274,723
Connecticut	2,811,000	31,229	1,545,836	551,431	580,454	9,925,758
New York	19,996,000	357,075	8,998,290	5,210,266	4,962,158	66,430,892
New Jersey	3,069,000	40,916	1,657,098	493,279	519,241	8,139,104
Pennsylvania	13,700,000	190,280	6,439,075	2,738,572	2,738,572	36,970,722
Delaware	315,000	4,141	157,358	44,665	49,628	647,643
Maryland	1,528,000	20,378	743,892	272,037	286,355	3,740,502
Virginia	2,102,000	35,037	1,072,132	251,541	295,930	3,340,464
North Carolina	1,256,000	20,597	716,158	96,680	101,768	1,129,222
South Carolina	235,000	3,911	175,995	4,336	4,336	59,620
Georgia	578,000	9,175	543,344	16,642	16,642	230,325
Florida	155,000	1,938	155,040	370	528	6,660
Alabama	617,000	9,353	598,779	13,298	14,147	169,284
Mississippi	576,000	8,471	489,624	11,069	11,069	130,061
Louisiana	466,000	6,661	391,667	38,984	38,984	428,824
Texas	651,000	9,579	586,235	83,899	83,315	904,431
Arkansas	932,000	12,268	615,363	29,701	29,701	326,711
Tennessee	2,531,000	38,937	1,164,216	229,088	208,262	2,673,457
West Virginia	1,933,000	27,609	831,031	289,841	353,465	3,307,086
Kentucky	3,387,000	59,556	1,422,646	313,200	313,200	3,210,300
Ohio	12,453,000	166,035	4,856,524	2,748,900	2,499,000	31,447,416
Michigan	12,880,000	148,048	4,379,260	1,507,232	1,256,027	16,142,455
Indiana	6,779,000	94,151	2,440,394	1,762,560	1,468,800	13,730,342
Illinois	12,371,000	142,198	5,195,915	4,298,125	3,306,250	31,591,219
Wisconsin	8,955,000	107,895	4,208,984	1,850,228	1,682,025	12,951,596
Minnesota	5,263,000	61,923	2,105,382	2,457,000	2,047,500	11,425,050
Iowa	12,381,000	137,563	5,076,075	4,355,625	3,787,500	21,124,781
Missouri	6,653.000	78,275	2,594,816	1,575,000	1,312,500	11,418,750
Kansas	7,011,000	87,638	3,645,741	3,800,000	3,040,000	16,150,000
Nebraska	3,951,000	48,777	1,422,357	2,593,175	1,994,750	9,102,044
California	4,887,000	57,491	3,078,643	1,127,160	939,300	12,962,340
Oregon	1,322,000	12,587	475,769	446,250	357,000	3,860,063
Nevada	355,000	4,733	230,734	135,000	150,000	978,750
Colorado	747,000	7,860	455,487	87,600	87,600	867,240
Arizona	84,000	1,204	58,153	22,950	25,500	298,350
Dakota	2,700,000	36,000	1,134,000	1,375,000	1,100,000	5,417,500
Idaho	252,000	3,150	131,040	144,383	125,550	1,516,022
Montana	262,000	3,198	131,118	156,750	142,500	1,625,498
New Mexico	35,000	501	11,222	18,900	21,000	274,050
Utah	853,000	9,591	310,748	159,129	122,409	949,946
Washington	1,136,000	10,422	397,599	190,944	159,120	1,363,340
Wyoming	112,000	1,208	67,406	93,500	85,000	958,375
Total	175,029,000	2,265,823	78,153,403	44,731,550	39,849,701	339,752,873

States and Territories.	Tobacco.			Cotton.		
	Pounds.	Acres.	Value.	Bales.	Acres.	Value.
Massachusetts	3,798,000	2,594	$455,714			
Connecticut	12,066,000	7,661	1,496,193			
New York	10,224,000	6,733	1,023,416			
Pennsylvania	23,392,000	23,392	2,456,160			
Maryland	28,552,000	43,065	2,084,303			
Virginia	107,711,000	164,445	7,970,649	14,821	44,913	$579,501
North Carolina	37,417,000	77,952	3,966,198	407,230	1,071,658	15,922,693
South Carolina				554,652	1,733,289	21,969,766
Georgia				960,025	3,047,698	39,413.826
Florida				73,837	273,473	4,357,860
Alabama				760,447	2,795,760	31,349,423
Mississippi				1,019,470	2,535,994	41,854,341
Louisiana				487,722	1,005,613	20,106,339
Texas				1,332,027	3,505,335	54,613.107
Arkansas	1,606,000	2,294	112,406	610,666	1,348,048	25,226,612
Tennessee	26,939,000	46,850	1,835,713	321,638	864,618	13,259,527
West Virginia	2,782.000	4,190	211,444			
Kentucky	209,423,000	265,093	13,612,526			
Ohio	33,767,000	36,703	2,127,306			
Indiana	9,593,000	13,324	862,395			
Illinois	4,963,000	5,908	446,645			
Wisconsin	31,196,000	27,127	2,963,625			
Missouri	14,514,000	16,493	1,015,969			
All other States and Territories, including Missouri, for cotton.	4,783,000	8,696	573,936	32,765	74,466	1,336,812
Total	562,736,000	752,520	43,265,598	6,575,300	18,300,865	269,989,812

Table showing the average yield per acre, and price per bushel, pound, or ton, of farm products for the year 1885.

States and Territories.	Corn.		Wheat.		Rye.		Oats.		Barley.	
	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Bushels.	Price per bushel.
Maine	32.3	$0 70	13.8	$1 25	12.2	$0 84	31.0	$0 40	22.4	$0 69
New Hampshire	33.8	71	15.4	1 24	12.5	83	34.7	42	22.4	69
Vermont	32.2	64	17.7	1 11	13.2	74	36.4	37	25.2	70
Massachusetts	34.0	70	15.7	1 25	11.3	81	31.0	43	25.2	72
Rhode Island	33.5	72	......	......	10.9	83	26.3	44	24.0	72
Connecticut	35.0	63	14.1	1 05	13.0	75	28.5	42	22.2	74
New York	30.7	58	15.4	96	11.0	67	27.9	36	22.0	71
New Jersey	32.0	53	9.7	95	10.8	65	26.6	37	19.5	75
Pennsylvania	32.5	49	9.7	96	8.2	66	26.3	36	18.5	70
Delaware	19.3	40	10.7	95	7.0	75	23.6	38	......	......
Maryland	22.0	46	9.5	91	7.8	65	22.3	35	21.7	68
Virginia	14.9	47	4.4	93	6.7	67	13.9	41	17.0	65
North Carolina	9.9	55	4.1	1 00	4.2	85	7.5	50	10.9	1 10
South Carolina	9.0	56	5.3	1 10	4.0	1 00	8.5	54	12.9	1 10
Georgia	11.3	58	6.2	1 09	4.5	1 13	9.0	53	14.1	1 09
Florida	9.0	70	......	......	......	......	9.7	67	......	......
Alabama	13.4	55	5.5	1 03	4.7	1 10	12.2	54	......	......
Mississippi	13.4	54	4.9	1 04	......	......	11.2	55	......	......
Louisiana	16.8	53	......	......	......	......	11.4	47	......	......
Texas	20.6	49	11.2	80	7.0	67	27.8	37	16.3	54
Arkansas	20.2	46	6.5	1 00	6.6	79	21.1	45	......	......
Tennessee	21.2	39	3.2	95	5.2	76	17.3	34	13.5	62
West Virginia	23.8	40	5.6	1 01	5.0	70	20.5	35	15.6	55
Kentucky	25.5	35	3.6	95	5.3	71	20.8	33	17.5	67
Ohio	37.1	32	10.2	91	11.0	60	37.3	27	20.5	67
Michigan	32.7	34	19.3	84	11.3	59	35.4	28	23.3	60
Indiana	35.5	29	10.6	86	11.0	59	26.8	25	17.3	55
Illinois	31.4	28	8.5	81	12.7	53	32.8	24	24.2	57
Wisconsin	30.1	31	11.5	76	12.3	52	33.8	26	22.4	47
Minnesota	28.4	32	11.1	70	15.3	48	34.9	25	23.8	41
Iowa	32.1	24	11.3	67	13.7	46	33.8	22	23.0	39
Missouri	31.3	25	7.4	77	10.4	56	22.3	26	22.3	52
Kansas	32.4	24	10.6	65	11.6	40	31.8	23	20.8	34
Nebraska	36.7	19	11.3	57	13.3	33	34.3	19	21.8	33
California	24.7	63	9.4	67	10.3	76	27.0	48	18.1	79
Oregon	22.8	70	15.9	69	14.9	75	30.0	37	20.2	49
Nevada	24.8	75	18.5	93	......	......	34.5	47	20.0	81
Colorado	34.5	68	19.8	83	17.8	68	37.3	46	24.0	60
Arizona	22.1	75	14.0	95	......	......	......	......	20.0	80
Dakota	23.9	28	12.8	63	12.0	56	37.5	23	25.0	37
Idaho	21.5	82	18.5	75	11.9	58	30.3	40	26.0	75
Montana	25.0	80	20.4	77	......	......	33.1	42	30.2	77
New Mexico	20.5	78	14.0	1 02	......	......	20.4	40	19.4	84
Utah	29.8	60	19.9	61	9.5	51	30.5	36	22.0	52
Washington	26.4	71	17.5	72	15.1	64	38.5	33	27.0	48
Wyoming	......	......	20.8	80	......	......	32.0	44	......	......
Average	26.5	32.8	10.4	77.1	10.2	57.9	27.6	28.5	21.4	56.3

States and Territories.	Buckwheat.		Potatoes.		Hay.		Tobacco.		Cotton.	
	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Tons.	Price per ton.	Pounds.	Price per pound.	Bales.	Price per pound.
								Cents.		*Cents.*
Maine	17.5	$0 54	100	$0 42	.85	$11 95	......	......	......	......
New Hampshire	20.1	54	102	44	.80	12 75	......	......	......	......
Vermont	20.5	53	98	35	.90	11 00	......	......	......	......
Massachusetts	11.1	55	100	57	1.05	18 50	1,464	12.0	......	......
Rhode Island	7.9	78	105	56	.80	18 30	......	......	......	......
Connecticut	12.6	60	90	55	.95	18 00	1,575	13.4	......	......
New York	14.8	53	56	45	1.05	12 75	1,520	10.0	......	......
New Jersey	13.5	60	75	54	.95	16 50	......	......	......	......
Pennsylvania	14.2	54	72	47	1.00	13 50	1,000	10.5	......	......
Delaware	11.4	55	76	50	.90	14 50	......	......	......	......
Maryland	13.0	60	75	49	.95	13 75	663	7.3	......	......
Virginia	9.0	61	60	51	.85	13 28	655	7.4	.33	8.5
North Carolina	8.4	65	61	57	.95	11 68	430	10.6	.38	8.5
South Carolina	......	......	60	75	1.00	13 75	......	......	.32	8.5
Georgia	......	......	63	94	1.00	13 84	......	......	.315	8.5
Florida	......	......	80	1 00	.70	18 00	......	......	.27	13.0
Alabama	......	......	66	97	.94	12 73	......	......	.272	8.5
Mississippi	......	......	63	85	1.00	11 75	......	......	.402	8.5
Louisiana	......	......	70	84	1.00	11 00	......	......	.485	8.5
Texas	......	......	68	90	.95	10 78	......	......	.38	8.2
Arkansas	......	......	76	66	1.00	11 00	700	7.0	.453	8.5
Tennessee	10.3	66	65	46	1.10	11 67	575	7.0	.372	8.5
West Virginia	10.5	61	70	43	.82	11 41	664	7.6	......	......
Kentucky	9.5	67	67	42	1.00	10 25	790	6.5	......	......

Table showing the average yield per acre, and price per bushel, &c.—Continued.

States and Territories.	Buckwheat.		Potatoes.		Hay.		Tobacco.		Cotton.	
	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Tons.	Price per ton.	Pounds.	Price per pound.	Bales.	Price per pound.
								Cents.		*Cents.*
Ohio	14.0	$0 65	75	$0 39	1.10	$11 44	920	6.3	....	....
Michigan	12.8	58	87	34	1.20	10 71	....	....	....	....
Indiana	10.2	65	72	36	1.20	7 79	720	9.0	....	....
Illinois	12.5	64	87	42	1.30	7 35	840	9.0	....	....
Wisconsin	10.0	69	83	47	1.10	7 00	1,150	9.5	....	....
Minnesota	11.2	70	85	40	1.20	4 65	....	....	....	....
Iowa	11.8	68	90	41	1.15	4 85	....	....	....	....
Missouri	10.3	68	85	39	1.20	7 25	880	7.0	....	....
Kansas	12.7	62	80	52	1.25	4 25				
Nebraska	12.5	66	81	36	1.30	3 51				
California	20.1	68	85	63	1.20	11 50				
Oregon	10.7	62	105	36	1.25	8 65				
Nevada	....	....	75	65	.90	7 25				
Colorado	....	....	95	61	1.00	9 90				
Arizona	....	....	70	69	.90	13 00	550	12.0	....	....
Dakota	8.1	69	75	42	1.25	3 94				
Idaho	....	....	80	52	1.15	10 50				
Montana	....	....	82	50	1.10	10 37				
New Mexico	....	....	70	32	.90	14 50				
Utah	....	....	90	36	1.30	5 97				
Washington	....	....	109	35	1.20	7 14				
Wyoming	....	....	93	60	1.10	10 25				
Average	13.8	55.9	77.2	44.7	1.12	8 71	747.8	7.7	.359	8.5

Table showing the average cash value per acre of farm products for the year 1885.

States and Territories.	Corn.	Wheat.	Rye.	Oats.	Barley.	Buckwheat.	Potatoes.	Tobacco.	Hay.	Cotton.
Maine	$22 62	$17 20	$10 20	$12 40	$15 46	$9 45	$42 00	....	$10 16	......
New Hampshire	24 03	19 15	10 38	14 56	15 52	10 80	44 88	....	10 20	......
Vermont	20 60	19 67	9 77	13 47	17 64	10 87	34 30	....	9 90	......
Massachusetts	23 80	19 68	9 15	13 34	18 22	6 05	57 00	$175 68	19 43	......
Rhode Island	24 10	....	9 02	11 57	17 39	6 21	58 80	....	14 64	......
Connecticut	22 03	14 84	9 75	11 96	16 43	7 56	49 50	195 30	17 10	......
New York	17 81	14 76	7 37	10 05	15 62	7 84	25 20	152 00	13 39	......
New Jersey	16 96	9 26	7 02	9 86	14 60	8 10	40 50	....	15 68	......
Pennsylvania	15 93	9 27	5 41	9 48	12 95	7 67	33 84	105 00	13 50	......
Delaware	7 71	10 20	5 25	8 98	....	6 25	38 00	....	13 05	......
Maryland	10 13	8 68	5 07	7 80	14 74	7 80	36 75	48 40	13 06	......
Virginia	7 02	4 05	4 49	5 72	11 05	5 49	30 60	48 47	11 29	$12 90
North Carolina	5 45	4 09	3 57	3 74	12 00	5 53	34 77	50 88	11 10	14 86
South Carolina	5 07	5 85	4 00	4 58	14 30	....	45 00	....	13 75	12 68
Georgia	6 53	6 77	5 08	4 78	15 39	....	59 22	....	13 84	12 93
Florida	6 33	....	....	6 49	....	....	80 00	....	12 61	15 94
Alabama	7 36	5 62	5 17	6 61	....	....	64 02	....	11 97	11 21
Mississippi	7 22	5 14	....	6 14	....	....	57 80	....	11 75	16 50
Louisiana	8 90	....	....	5 35	....	....	58 60	....	11 00	19 99
Texas	10 11	8 97	4 69	10 27	8 80	....	61 20	....	10 24	15 58
Arkansas	9 28	6 49	5 20	9 51	....	....	50 16	49 00	11 00	18 71
Tennessee	8 26	3 09	3 95	5 90	8 37	6 80	29 90	40 25	12 84	15 34
West Virginia	9 51	5 61	3 50	7 18	8 58	6 40	30 10	50 46	9 36	......
Kentucky	8 93	3 38	3 76	6 86	11 73	6 44	28 14	51 35	10 25	......
Ohio	11 83	9 28	6 60	10 08	13 74	9 10	29 25	57 96	12 58	......
Michigan	11 12	16 17	6 67	9 91	13 98	7 42	29 58	....	12 85	......
Indiana	10 29	9 10	6 49	6 70	9 52	6 63	25 92	64 80	9 35	......
Illinois	8 80	6 89	6 73	7 88	13 79	8 00	36 54	75 60	9 56	......
Wisconsin	10 23	8 74	6 40	8 79	10 53	6 90	39 01	109 25	7 70	......
Minnesota	9 09	7 78	7 34	8 72	9 76	7 84	34 00	....	5 58	......
Iowa	7 71	7 57	6 30	7 44	8 97	8 02	36 90	....	5 58	......
Missouri	7 82	5 72	5 82	5 81	11 60	7 00	33 15	61 60	8 70	......
Kansas	7 78	6 86	4 64	7 31	7 07	7 88	41 60	....	5 31	......
Nebraska	6 97	6 44	4 39	6 52	7 19	8 26	29 16		4 56	......
California	16 82	6 31	7 83	12 96	14 30	13 60	53 55		13 80	......
Oregon	15 99	10 96	11 25	11 09	9 90	6 60	37 80		10 81	......
Nevada	18 60	17 01	....	16 21	16 20	....	48 75		6 53	......
Colorado	23 43	16 24	12 06	17 17	14 40	....	57 95		9 90	......
Arizona	16 54	13 34	....	....	16 00	....	48 30		11 70	......
Dakota	8 11	8 04	6 72	8 62	9 25	5 60	31 50	66 00	4 93	......
Idaho	17 59	13 88	6 90	12 11	19 50	....	41 60		12 08	......
Montana	20 00	15 75	....	13 92	23 10	....	41 00		11 41	......
New Mexico	16 02	14 25	....	8 15	16 40	....	22 40		13 05	......
Utah	17 86	12 13	4 85	10 99	11 44	....	32 40		7 76	......
Washington	18 75	12 58	9 64	12 71	12 96	....	38 15		8 57	......
Wyoming	....	16 60	....	14 08	....	....	55 80		11 28	......
Average	8 69	8 05	5 92	7 88	12 04	7 72	34 49	57 49	9 78	14 75

A general summary, showing the estimated quantities, number of acres, and aggregate value of the crops of the farm in 1885.

Products.	Quantity produced.	Number of acres.	Value.
Indian corn ....bushels..	1,936,176,000	73,130,150	$635,674,630
Wheat........do....	357,112,000	34,189,246	275,320,390
Rye........do....	21,756,000	2,129,301	12,594,820
Oats........do....	629,409,000	22,783,630	179,631,860
Barley........do....	58,360,000	2,729,359	32,867,696
Buckwheat........do....	12,626,000	914,394	7,057,363
Potatoes........do....	175,029,000	2,265,823	78,153,403
Total........	3,190,468,000	138,141,903	1,221,300,162
Tobacco........pounds..	562,736,000	752,520	43,265,598
Hay........tons..	44,731,550	39,849,701	389,752,873
Cotton........bales..	6,575,300	18,300,865	269,989,812
Grand total........	....	197,044,989	1,924,308,445

Table showing the average yield and cash value per acre, and price per unit of quantity, of farm products for the year 1885.

Products.	Average yield per acre.	Average price per unit of quantity.	Average value per acre.	Products.	Average yield per acre.	Average price per unit of quantity.	Average value per acre.
Indian corn ..bushels.	26.5	$0 32.8	$8 69	Buckwheat .bushels.	13.8	$0 55.9	$7 72
Wheat........do..	10.4	77.1	8 05	Potatoes........do..	77.2	44.7	34 49
Rye........do..	10.2	57.9	5 92	Tobacco.....pounds.	747.8	7.7	57 49
Oats........do..	27.6	28.5	7 88	Hay........tons.	1.12	8 71	9 78
Barley........do..	21.4	56.3	12 04	Cotton........bales.	.359	*8.5	14 75

*Per pound.

FARM ANIMALS.

Table showing the estimated number of animals on farms, total value of each kind, and average price, January, 1886.

States and Territories.	Horses.			Mules.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Maine........	90,288	$88 30	$7,972,453	....	....	....
New Hampshire........	49,138	82 91	4,074,211	....	....	....
Vermont........	79,202	83 68	6,627,271	....	....	....
Massachusetts........	62,663	103 15	6,463,534	....	....	....
Rhode Island........	9,905	102 58	1,016,071	....	....	....
Connecticut........	47,934	99 66	4,777,165	....	....	....
New York........	647,845	93 22	60,389,110	5,107	$107 33	$548,113
New Jersey........	90,741	103 54	9,395,110	9,407	119 47	1,123,900
Pennsylvania........	577,531	94 10	54,346,474	23,670	109 99	2,603,488
Delaware........	22,330	97 29	2,172,384	4,061	113 74	461,915
Maryland........	126,496	81 62	10,324,641	13,226	108 17	1,430,626
Virginia........	233,871	69 56	16,267 609	34,342	85 53	2,937,296
North Carolina........	142,579	74 53	10,625,894	86,452	83 19	7,192,173
South Carolina........	62,789	88 97	5,586,481	71,119	98 30	6,990,978
Georgia........	106,834	81 58	8,715,984	143,843	96 50	13,880,850
Florida........	29,419	79 78	2,347,183	11,558	97 21	1,123,586
Alabama........	123,342	70 79	8,731,643	132,348	84 03	11,120,818
Mississippi........	125,154	69 43	8,688,875	147,512	88 57	13,064,504
Louisiana........	112,975	56 41	6,372,937	78,863	86 24	6,801,147
Texas........	998,862	35 89	35,851,466	175,515	54 50	9,566,081
Arkansas........	169,625	54 58	9,258,528	114,317	69 77	7,976,394
Tennessee........	288,604	65 72	18,966,758	187,208	69 69	13,046,443
West Virginia........	131,621	60 85	8,008,848	6,412	75 50	484,106
Kentucky........	383,034	63 69	24,394,384	124,185	69 38	8,616,370
Ohio........	753,680	79 16	59,659,185	23,999	87 68	2,104,238
Michigan........	428,650	83 58	35,826,292	5,775	99 60	575,190
Indiana........	635,362	75 47	47,950,766	54,943	81 97	4,503,828
Illinois........	1,048,759	75 21	78,872,127	124,473	82 43	10,259,734
Wisconsin........	396,700	78 04	30,957,952	8,010	91 51	732,995
Minnesota........	334,588	80 00	26,767,040	10,553	98 14	1,035,689

Table showing the estimated number of animals on farms, total value, &c.—Cont'd.

States and Territories.	Horses.			Mules.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Iowa	945,445	$72 18	$68,245,526	48,537	$86 09	$4,178,575
Missouri	737,208	58 52	43,138,118	212,615	67 76	14,407,602
Kansas	549,406	69 98	38,446,250	79,615	89 64	7,136,992
Nebraska	341,419	74 50	25,435,716	28,827	94 48	2,723,641
California	275,834	63 00	17,377,542	31,551	77 65	2,450,081
Oregon	159,786	52 57	8,399,155	3,005	64 41	193,550
Nevada	42,126	61 13	2,574,968	1,563	80 01	125,052
Colorado	108,570	59 09	6,415,942	7,560	80 33	607,311
Arizona	9,681	53 00	513,093	1,242	94 50	117,369
Dakota	206,388	77 86	16,069,137	11,616	100 40	1,166,247
Idaho	44,318	60 00	2,659,080	2,388	87 00	207,756
Montana	120,750	62 68	7,568,028	8,960	84 15	753,984
New Mexico	19,796	39 37	779,288	10,698	54 60	584,155
Utah	52,464	46 52	2,440,808	3,409	62 94	214,554
Washington	81,945	67 45	5,526,821	1,009	85 00	85,765
Wyoming	72,000	53 13	3,825,360	3,100	80 00	248,000
Total	12,077,657	71 27	860,823,208	2,052,593	79 60	163,381,096

States and Territories.	Milch cows.			Oxen and other cattle.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Maine	165,353	$30 10	$4,977,125	187,030	$29 89	$5,590,174
New Hampshire	97,070	29 83	2,895,598	136,169	31 32	4,264,412
Vermont	218,940	28 63	6,268,252	176,808	26 06	4,607,683
Massachusetts	169,968	32 40	5,506,963	108,382	31 67	3,432,457
Rhode Island	22,543	34 00	766,462	13,024	36 89	480,490
Connecticut	123,426	32 92	4,063,184	106,724	33 61	3,586,535
New York	1,510,300	29 60	44,704,880	868,409	32 08	27,860,665
New Jersey	171,214	34 36	5,882,913	69,248	34 65	2,399,115
Pennsylvania	902,127	30 10	27,154,023	858,474	27 36	23,484,680
Delaware	28,399	28 50	809,372	26,605	28 53	758,912
Maryland	131,063	30 15	3,951,549	138,196	25 08	3,466,107
Virginia	247,807	21 81	5,404,671	423,803	18 42	7,804,759
North Carolina	238,955	16 65	3,978,601	423,619	10 24	4,339,469
South Carolina	143,315	19 93	2,856,268	214,711	11 18	2,400,020
Georgia	341,013	18 35	6,257,589	610,811	9 91	6,053,141
Florida	47,915	16 00	766,649	565,600	8 79	4,970,606
Alabama	285,290	15 92	4,541,817	432,090	10 15	4,384,375
Mississippi	277,523	15 96	4,429,267	420,457	9 89	4,158,822
Louisiana	153,313	19 00	2,912,947	252,863	11 93	3,016,048
Texas	700,876	20 29	14,220,774	4,023,177	13 00	52,298,087
Arkansas	276,104	17 98	4,964,350	442,173	11 26	4,979,796
Tennessee	326,417	20 00	6,528,340	475,406	13 43	6,386,604
West Virginia	166,252	25 42	4,226,126	289,519	18 05	5,226,327
Kentucky	307,767	28 53	8,780,593	529,071	21 18	11,208,055
Ohio	775,724	30 53	23,682,854	1,017,820	26 94	27,414,996
Michigan	420,362	30 38	12,770,598	506,644	25 52	12,929,152
Indiana	540,634	30 00	16,219,020	885,665	25 42	22,511,670
Illinois	923,194	31 57	29,303,085	1,485,903	26 04	38,699,757
Wisconsin	565,177	28 63	16,181,018	710,053	23 22	16,489,066
Minnesota	386,366	27 87	10,768,020	448,695	22 51	10,098,280
Iowa	1,230,695	28 80	35,444,016	2,074,919	24 26	50,332,980
Missouri	708,698	24 59	17,426,884	1,387,818	20 84	28,921,584
Kansas	575,095	28 46	16,367,204	1,494,259	22 94	34,273,065
Nebraska	309,106	30 80	9,520,465	1,535,457	24 69	37,916,598
California	236,378	38 75	9,159,648	627,907	28 66	17,994,559
Oregon	72,342	27 46	1,986,511	606,835	23 73	14,397,777
Nevada	16,841	39 00	656,799	288,235	23 55	6,788,320
Colorado	51,155	40 67	2,080,474	1,019,779	25 95	26,211,893
Arizona	13,847	31 00	429,257	238,931	20 00	4,778,620
Dakota	181,345	30 94	5,610,814	629,145	23 61	14,750,060
Idaho	22,271	35 00	779,485	290,131	22 00	6,382,882
Montana	25,300	37 00	936,100	725,700	22 08	16,023,456
New Mexico	17,932	26 00	466,232	1,151,857	18 00	20,733,426
Utah	42,013	30 86	1,296,521	162,846	23 88	3,888,526
Washington	56,730	32 00	1,815,360	286,358	26 00	7,445,308
Wyoming	6,233	38 00	236,854	1,280,916	25 00	32,022,900
Indian	....	....	....	627,000	22 00	13,794,000
Total	14,235,388	27 40	389,985,523	31,275,242	21 17	661,956,274

Table showing the estimated number of animals on farms, total value, &c.—Cont'd.

States and Territories.	Sheep.			Hogs.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Maine	537,407	$2 15	$1,156,771	70,702	$8 78	$620,760
New Hampshire	195,260	2 45	478,387	54,404	9 33	507,725
Vermont	378,174	2 86	1,082,031	74,115	6 90	511,112
Massachusetts	64,561	3 04	196,104	77,616	10 04	779,577
Rhode Island	20,449	3 75	76,684	14,395	9 80	141,071
Connecticut	53,477	3 25	173,575	61,782	8 24	508,833
New York	1,595,824	3 06	4,875,243	722,060	7 53	5,435,448
New Jersey	107,413	3 76	403,851	193,795	8 35	1,618,574
Pennsylvania	1,189,481	2 68	3,187,809	1,103,391	7 47	8,241,556
Delaware	22,294	2 80	62,368	44,431	6 10	271,028
Maryland	168,582	3 08	519,739	299,868	5 95	1,785,115
Virginia	463,127	2 24	1,035,922	875,256	3 66	3,206,063
North Carolina	468,816	1 28	600,084	1,346,558	3 24	4,357,460
South Carolina	112,935	1 72	194,250	567,181	3 40	1,927,962
Georgia	500,594	1 46	730,868	1,565,978	3 15	4,930,952
Florida	91,094	1 65	150,305	298,108	2 38	709,498
Alabama	337,047	1 40	471,866	1,351,152	3 15	4,261,533
Mississippi	276,103	1 50	413,878	1,212,144	3 04	3,685,645
Louisiana	116,385	1 65	192,466	580,790	3 10	1,800,449
Texas	6,802,615	1 70	11,582,812	2,411,727	2 76	6,656,367
Arkansas	234,021	1 57	367,881	1,692,265	2 48	4,197,065
Tennessee	603,780	1 60	967,255	2,122,646	3 20	6,788,222
West Virginia	624,912	1 88	1,174,210	416,133	3 66	1,522,123
Kentucky	903,223	2 24	2,024,665	2,032,138	3 48	7,068,996
Ohio	4,753,034	2 09	9,918,156	2,442,457	4 80	11,720,864
Michigan	2,269,607	2 11	4,788,871	840,682	5 27	4,430,393
Indiana	1,038,517	2 10	2,288,607	2,773,199	4 66	12,936,420
Illinois	1,005,653	2 19	2,205,196	3,967,961	4 76	18,897,017
Wisconsin	1,218,800	1 89	2,305,969	1,056,265	5 18	5,468,282
Minnesota	278,162	2 21	615,294	440,540	4 67	2,056,000
Iowa	467,580	2 28	1,067,204	4,849,008	5 07	24,596,107
Missouri	1,285,078	1 48	1,908,340	4,168,091	3 46	14,404,922
Kansas	1,190,163	1 60	1,898,667	2,275,178	4 86	11,059,640
Nebraska	448,673	2 15	965,993	2,312,784	5 08	11,748,943
California	6,060,698	1 81	10,961,268	1,027,598	4 15	4,266,586
Oregon	2,469,551	1 47	3,618,139	191,600	2 81	538,281
Nevada	661,261	1 73	1,145,436	14,399	4 55	65,517
Colorado	1,126,645	1 77	1,994,162	17,032	7 38	125,611
Arizona	896,002	1 70	1,523,203	10,149	4 50	45,671
Dakota	253,672	2 24	568,226	355,980	4 98	1,773,849
Idaho	210,375	2 10	441,788	26,762	5 60	149,867
Montana	718,750	2 12	1,523,391	19,298	6 26	120,805
New Mexico	4,328,755	1 60	6,934,666	17,492	5 55	97,082
Utah	651,767	2 08	1,356,588	27,554	7 16	197,357
Washington	544,548	2 25	1,223,491	66,779	4 81	321,286
Wyoming	518,466	2 07	1,072,188	2,500	6 50	16,250
Total	48,322,331	1 91	92,443,867	46,092,043	4 25	196,569,894

NUMBERS.

The interest in horse breeding has not abated during the past year. Improvement is rife in nearly all sections of the country, giving increase of value, so that the aggregate of horse values, notwithstanding the general tendency to decline, has slightly advanced. No other species of farm animals shows much increase of value.

In New England there is considerable interest in raising trotting stock. The stock laws of the Southern States, which require fencing in of stock, have resulted in the increase of horse raising, at the expense of other stock, as horses require a smaller area of pasture, and better repay expenses of raising. The South, however, does not yet raise all the horses required, making a market still for many horses grown in Kentucky and north of the Ohio. In Louisiana the wood pastures and old fields of the western parishes contain droves of a small horse of Spanish origin, which is much used by the creole and negro population for cultivating and general purposes. They are

easily and cheaply raised, and bear a low price, thus reducing the average value of the horses of the State. In some parts of Texas there is a growing interest in horse raising. Cross-bred colts from Mexican dams are produced in large numbers, selling, when grown, at $20 to $40, according to quality. A better cross from large American mares is worth $80 when full grown. The average value of Texas horses of all ages is less than half the average of the United States—$32.39 to $72.15. The Arkansas markets are flooded with Mexican mustangs, causing a reduction in price in some localities. Mustangs have been very generally distributed during the past year—considerably even in the Ohio River region—among better stock, where a tendency exists for heavier draft horses. The great variety of uses of horses admits of enlargement of demands for both large and small breeds. Minnesota horses are in demand farther west, and are beginning to be grown for the Dakota supply. Horse raising is to some extent taking the place of wheat. Numbers have increased largely in Kansas, partly owing to immigration and partly to the establishing of large stock farms. The bronchos, or Mexicans, are distributed extensively through the Pacific-coast States, reducing the average value by their numbers. The increase is very heavy in Idaho, Montana, Utah, and Washington from establishment of horse ranches. Oregon, California, and Minnesota show marked increase.

The increase in mules has been less proportionally than in horses during the past year, and is unequally distributed. Few are found in New England or in the States of the Northern border, but they become more numerous in the lower latitudes.

The largest increase of milch cows is in the States receiving immigration, and in the Territories where mining and other industries are increasing. The increase has been slow in several of the Western States on account of the low price of butter. There is indicated, however, a tendency to improvement in quality. It is recognized that the profits of a dairy, where the margin is small, may be sacrificed by the presence of a few poor cows. It is reported that a better feeling exists since the passage of the olemargarine bill.

There has been a considerable increase in other cattle, from a belief that beef will pay better than wheat and cotton and other tillage crops, declining less in unfavorable markets. A larger number of calves has been raised, and in the ranch regions cows have been retained in the herds, while bullocks have gone to market; and though there was heavy loss last winter in some districts, there is increase of numbers in in the feeding grounds of the plains and mountains.

Sheep have been reduced heavily in numbers, under the influence of low prices of wool, to such extent that the comparative scarcity, with increasing wool values in other parts of the world, has given prices an upward turn, and sheep are already coming into greater demand. In all parts of the world wool prices have recently been low, and numbers have decreased in other countries, causing the rise in value that has recently taken place.

The numbers of swine are also less than a year ago. The ravages of cholera have been so heavy, that stock hogs have not been kept up to the recent standard of supply. The reduction is also felt in the receipts of slaughtering establishments.

The total numbers of farm animals, compared with the figures of February, 1886, are as follows:

Stock.	1886.	1887.	Increase or decrease.
Horses	12,077,657	12,496,744	+ 419,087
Mules	2,052,593	2,117,141	+ 64,548
Milch cows	14,235,388	14,522,083	+ 286,695
Oxen and other cattle	31,275,242	33,511,750	+2,236,508
Sheep	48,322,331	44,759,314	−3,563,017
Swine	46,092,043	44,612,836	−1,479,207

VALUES.

The decline in values noticed in two preceding reports has not been active. It is most manifest in cattle, which have increased in numbers. As to horses, sheep, and swine, average values have slightly increased during the year. It is to be hoped that the depression in agricultural values has reached its lowest ebb. The averages are as follows:

Stock.	1886.	1887.	Increase or decrease.
Horses	$71 27	$72 15	+$0 88
Mules	79 60	78 91	− 69
Milch cows	27 40	26 08	− 1 32
Oxen and other cattle	21 17	19 79	− 1 38
Sheep	1 91	2 01	+ 10
Swine	4 25	4 48	+ 23

The course of prices of the last ten years is thus shown as indicated by the average price of all animals of each species on the 1st of January:

Years.	Horses.	Mules.	Cows.	Other cattle.	Sheep.	Swine.
1878	$58 16	$63 70	$26 41	$17 14	$2 25	$4 98
1879	52 41	56 06	21 73	15 39	2 07	3 18
1880	54 75	61 26	23 27	16 10	2 21	4 28
1881	58 44	69 79	23 95	17 33	2 39	4 70
1882	58 52	71 35	25 89	19 89	2 37	5 98
1883	70 59	79 49	30 21	21 80	2 53	6 75
1884	74 64	84 22	31 37	23 52	2 37	5 57
1885	73 70	82 38	29 70	23 25	2 14	5 02
1886	71 27	79 60	27 40	21 17	1 91	4 25
1887	72 15	78 91	26 08	19 79	2 01	4 48

The year 1879 was the date of lowest prices recorded since the collection of these statistics. The decline from 1873 to 1879 was almost continuously progressive and very heavy. A sharp rise followed, culminating in 1884. Sheep were highest in 1883, commencing a decline, due to large importation of foreign wool, a year before the retrograde movement in other values commenced. Hogs were also highest in 1883, on account of the poor corn harvest of that year. Hogs always sympathize with corn in price movements, fluctuating with good and bad harvests, aside from the tendency of prices from other causes.

The aggregate values of farm animals and a comparison with values of last year are given as follows:

Stock.	1886.	1887.	Increase or decrease.
Horses	$860,823,208	$901,685,755	+$40,862,547
Mules	163,381,096	167,057,538	+ 3,676,442
Milch cows	389,985,523	378,789,589	− 11,195,934
Oxen and other cattle	661,956,274	663,137,926	+ 1,181,652
Sheep	92,443,867	89,872,839	− 2,571,028
Swine	196,569,894	200,043,291	+ 3,473,397
Total	2,365,159,862	2,400,586,938	+ 35,427,076

There is an increase in the totals for horses, mules, oxen and other cattle, and swine. The decline is heaviest in milch cows, attributed to discouragement over the prices of butter, which farmers claim have been reduced by the abundance of oleomargarine sold as butter. The feeling is better under the law regulating the sale of imitation butter compounds, and prices of cows are already appreciating in consequence.

Table showing the estimated number and value of animals on farms, January 1, 1887.

States and Territories.	Horses.			Mules.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Maine	92,094	$88 69	$8,167,650	....	....	....
New Hampshire	49,384	83 91	4,143,889	....	....	....
Vermont	82,370	82 31	6,780,071	....	....	....
Massachusetts	63,916	106 64	6,816,300	....	....	....
Rhode Island	9,955	106 62	1,061,443	....	....	....
Connecticut	48,413	100 00	4,841,242	....	....	....
New York	660,802	98 39	65,017,137	5,158	$110 [illegible]	$571,860
New Jersey	91,648	103 25	9,463,136	9,407	120 [illegible]	1,136,749
Pennsylvania	583,306	94 87	55,337,053	23,670	110 51	2,615,691
Delaware	22,330	95 63	2,135,491	4,061	118 23	480,130
Maryland	129,026	83 15	10,728,077	13,358	96 16	1,284,544
Virginia	238,543	70 11	16,725,673	35,372	86 46	3,058,096
North Carolina	142,579	75 14	10,713,012	88,181	79 32	6,994,096
South Carolina	64,673	88 17	5,701,926	73,253	94 04	6,888,383
Georgia	107,902	81 16	8,757,335	146,720	95 29	13,980,[illegible]52
Florida	31,184	81 62	2,545,222	11,789	93 93	1,107,284
Alabama	127,042	68 89	8,751,535	134,995	82 93	11,194,624
Mississippi	130,160	70 59	9,187,566	153,412	84 44	12,953,958
Louisiana	114,105	57 27	6,534,952	81,229	84 66	6,876,876
Texas	1,038,816	32 39	33,642,055	186,046	51 80	9,637,232
Arkansas	174,714	60 07	10,495,903	117,747	72 75	8,566,439
Tennessee	294,376	66 81	19,667,265	190,952	70 81	13,521,572
West Virginia	135,570	65 72	8,910,107	6,540	75 75	495,399
Kentucky	386,864	67 83	26,242,445	122,943	72 26	8,883,535
Ohio	761,217	81 97	62,398,601	24,479	87 98	2,153,571
Michigan	454,369	84 87	38,563,565	5,486	101 39	556,208
Indiana	635,262	77 50	49,243,727	53,844	83 49	4,495,201
Illinois	1,059,247	76 61	81,152,417	125,718	83 33	10,476,670
Wisconsin	408,601	80 72	32,983,234	8,010	94 24	754,877
Minnesota	354,663	82 90	29,402,052	10,447	99 23	1,036,624
Iowa	973,808	73 86	71,926,052	48,052	87 13	4,186,622
Missouri	759,324	58 66	44,542,180	218,993	67 58	14,799,633
Kansas	593,358	71 23	42,263,123	83,596	87 57	7,320,901
Nebraska	382,389	76 75	29,349,719	40,358	92 09	3,716,460
California	289,626	64 00	18,534,948	36,284	83 67	3,035,912
Oregon	167,775	53 92	9,045,603	3,155	72 60	229,068
Nevada	44,654	55 15	2,462,449	1,657	73 18	121,251
Colorado	123,770	58 00	7,178,918	8,165	83 92	685,224
Arizona	10,165	52 00	528,580	1,863	74 00	137,862
Dakota	227,027	77 60	17,618,192	11,964	99 85	1,194,622
Idaho	48,750	55 00	2,681,250	2,436	86 50	210,714
Montana	129,203	50 58	6,535,088	9,229	71 75	662,181
New Mexico	20,786	35 89	745,944	10,912	47 70	520,501
Utah	56,136	43 94	2,466,490	3,579	60 10	215,082
Washington	94,237	63 87	6,018,458	1,231	83 06	102,247
Wyoming	82,500	44 59	3,678,675	2,850	69 78	198,887
Total	12,496,744	72 15	901,685,755	2,117,141	78 91	167,057,538

Table showing the estimated number and value of animals on farms—Continued.

States and Territories.	Milch cows.			Oxen and other cattle.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Maine	165,849	$29 50	$4,892,546	185,160	$28 13	$5,208,833
New Hampshire	98,041	30 20	2,960,838	138,892	30 64	4,255,574
Vermont	221,129	27 22	6,019,131	178,576	27 25	4,865,493
Massachusetts	175,067	35 00	6,127,345	110,550	31 24	3,453,157
Rhode Island	22,656	35 50	804,288	13,154	32 86	432,243
Connecticut	124,660	33 33	4,154,918	109,926	31 69	3,484,055
New York	1,495,197	31 30	46,799,666	859,725	33 16	28,512,267
New Jersey	172,926	36 00	6,225,336	69,940	33 56	2,347,186
Pennsylvania	911,148	29 00	26,423,292	867,059	26 14	22,663,198
Delaware	28,683	30 50	874,832	27,137	26 64	722,930
Maryland	133,684	29 50	3,943,678	139,578	24 86	3,469,213
Virginia	255,241	23 00	5,870,543	428,041	18 59	7,958,353
North Carolina	241,345	15 75	3,801,184	419,383	9 99	4,188,043
South Carolina	144,748	18 25	2,641,651	216,858	10 67	2,314,199
Georgia	337,603	17 60	5,941,813	604,703	9 88	5,975,851
Florida	49,832	15 55	774,888	565,600	8 54	4,827,622
Alabama	288,143	16 65	4,797,581	436,411	9 86	4,304,325
Mississippi	283,073	14 40	4,076,251	424,662	9 00	3,823,653
Louisiana	157,912	15 25	2,408,158	265,506	12 25	3,251,655
Texas	735,920	15 84	11,656,973	6,034,766	12 14	73,292,232
Arkansas	289,909	16 23	4,705,223	451,016	10 71	4,828,896
Tennessee	336,210	21 00	7,060,410	470,652	14 06	6,619,257
West Virginia	167,915	26 50	4,449,748	286,624	20 32	5,824,486
Kentucky	310,845	27 23	8,464,309	534,362	23 82	12,727,483
Ohio	775,724	29 18	22,635,626	997,464	26 90	26,827,597
Michigan	432,973	30 27	13,106,093	521,843	25 84	13,484,860
Indiana	551,447	27 38	15,098,619	903,378	24 17	21,831,037
Illinois	937,476	29 33	27,496,171	1,500,762	25 27	37,918,859
Wisconsin	548,222	25 70	14,089,305	681,651	23 48	16,005,369
Minnesota	417,275	25 50	10,640,513	475,617	22 17	10,544,186
Iowa	1,243,002	26 18	32,541,792	2,116,417	22 38	47,369,232
Missouri	729,959	23 50	17,154,037	1,429,453	19 20	27,441,923
Kansas	609,601	26 27	16,014,218	1,583,915	22 41	35,501,864
Nebraska	333,834	26 63	8,889,999	1,048,200	24 29	25,460,778
California	243,469	33 22	8,088,040	659,302	20 64	13,607,595
Oregon	75,959	31 50	2,392,709	643,245	23 77	15,289,941
Nevada	17,683	36 10	638,356	317,059	21 92	6,949,933
Colorado	57,294	38 00	2,177,172	1,070,768	22 20	23,768,479
Arizona	15,232	23 33	355,363	243,710	19 00	4,630,490
Dakota	199,480	28 00	5,585,440	710,934	22 31	15,859,862
Idaho	24,498	35 00	857,430	339,453	21 50	7,298,240
Montana	29,095	37 50	1,091,063	812,784	23 10	18,775,310
New Mexico	18,829	25 67	483,340	1,220,968	17 87	21,824,802
Utah	44,534	30 00	1,336,020	219,842	20 46	4,498,871
Washington	62,403	33 00	2,059,299	300,676	23 44	7,047,849
Wyoming	6,358	29 00	184,382	1,255,298	22 95	28,815,365
Indian Territory	....	....	....	620,730	21 00	13,035,330
Total	14,522,083	26 08	378,789,589	33,511,750	19 79	663,137,926

States and Territories.	Sheep.			Hogs.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Maine	526,659	$2 79	$1,470,695	71,056	$8 60	$611,080
New Hampshire	195,260	2 77	539,894	53,860	9 38	504,938
Vermont	378,174	2 81	1,061,459	74,856	7 88	589,688
Massachusetts	63,270	3 34	211,164	76,840	10 09	775,319
Rhode Island	20,245	3 63	73,540	14,107	9 65	136,130
Connecticut	53,477	3 51	187,474	61,164	8 80	538,245
New York	1,579,366	3 30	5,213,558	700,398	7 35	5,145,331
New Jersey	106,339	3 58	381,013	189,919	8 29	1,574,526
Pennsylvania	1,094,323	2 81	3,072,859	1,070,289	7 24	7,750,178
Delaware	22,294	2 93	65,377	42,654	7 15	304,977
Maryland	165,210	3 30	544,383	275,879	6 49	1,789,077
Virginia	449,233	2 30	1,034,134	787,730	4 11	3,237,570
North Carolina	450,063	1 28	576,081	1,279,230	3 35	4,286,700
South Carolina	108,418	1 53	166,314	550,166	3 76	2,068,625
Georgia	465,552	1 42	659,780	1,518,999	2 90	4,405,098
Florida	90,183	1 78	160,886	298,108	2 45	729,768
Alabama	323,565	1 42	458,071	1,310,617	2 96	3,832,703
Mississippi	242,971	1 44	348,664	1,115,172	3 00	3,345,516
Louisiana	111,730	1 55	173,015	551,751	3 18	1,754,567
Texas	4,761,831	1 62	7,718,928	2,532,313	2 80	7,090,476

Table showing the estimated number and value of animals on farms—Continued.

States and Territories.	Sheep.			Hogs.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Arkansas	224,660	$1 52	$341,933	1,523,129	$2 65	$4,036,293
Tennessee	561,515	1 51	846,877	1,910,381	3 10	5,922,181
West Virginia	593,666	2 18	1,297,042	433,778	4 11	1,780,448
Kentucky	858,062	2 33	1,997,569	1,808,603	3 82	6,905,247
Ohio	4,562,913	2 53	11,533,675	2,320,334	5 59	12,967,882
Michigan	2,156,127	2 54	5,485,187	823,868	5 82	4,794,419
Indiana	1,034,091	2 48	2,567,131	2,495,879	5 37	13,396,880
Illinois	925,201	2 44	2,250,359	3,650,524	5 48	19,997,572
Wisconsin	1,072,541	2 08	2,230,462	1,003,452	5 30	5,314,284
Minnesota	278,162	2 36	655,229	422,918	4 60	1,943,730
Iowa	425,498	2 40	1,020,315	4,461,087	5 17	23,065,603
Missouri	1,182,272	1 67	1,968,838	3,876,325	3 62	14,032,297
Kansas	1,106,852	1 75	1,939,758	2,161,419	5 53	11,955,240
Nebraska	439,700	1 92	841,004	2,382,168	5 49	13,073,336
California	6,069,698	1 77	10,728,192	1,017,322	3 78	3,841,409
Oregon	2,592,029	1 42	3,670,173	229,920	2 86	656,423
Nevada	674,486	1 71	1,153,371	14,543	5 32	77,339
Colorado	1,149,178	1 61	1,845,579	21,290	6 88	146,424
Arizona	627,201	1 60	1,003,522	13,701	4 00	54,804
Dakota	256,209	2 43	623,100	427,176	5 42	2,314,013
Idaho	231,413	2 25	520,679	28,100	5 25	147,525
Montana	754,688	2 34	1,762,197	20,263	5 88	119,168
New Mexico	4,025,742	1 48	5,958,098	20,990	6 27	131,565
Utah	658,285	2 04	1,343,692	28,656	8 27	237,052
Washington	555,439	2 00	1,110,878	90,152	4 26	384,049
Wyoming	534,020	1 96	1,047,480	2,750	6 40	17,596
Indian	....	....	....	850,000	2 60	2,210,000
Total	44,759,314	2 01	89,872,839	44,612,836	4 48	200,043,291

WHEAT AND CORN.

SUPPLY AND DEMAND FOR FIVE YEARS.

A resolution of the House of Representatives of the United States called upon the Department of Agriculture to give the amount of wheat and corn on hand in this country, where located, with probable requirements, to September 1, 1886, as compared with amounts on hand at similar periods during the previous five years; the number of acres of spring and winter wheat growing, each respectively, to produce the crops of 1886, with acreage for each of the five preceding years; the amount of wheat and corn, each respectively, likely to be required by each importing country, with present surplus on hand in each exporting country to supply such requirements until September 1, 1886; the area of wheat sown in all other countries for the crop of 1886, with probable surplus or shortage in each country.

On the 29th of May a report was made by the Statistician and communicated to the House, showing concisely:

(1) (*a*) Stocks on hand in the United States; (*b*) requirements to September 1.

(2) Acreage of crop of 1886.

(3) (*a*) Production in Europe; (*b*) European commercial supply.

(4) European stocks on hand.

(5) The coming crops: (*a*) Wheat; (*b*) corn.

It makes the normal consumption of wheat-consuming countries, not including the small amount produced in countries where other grains constitute the diet of the people, about 2,165,000,000 bushels, and finds that the deficency of last year was 89,000,000, and the sur-

plus of 1884 125,000,000. It finds a deficiency in 1886 in countries where the harvest is finished of 32,000,000, the probability of an average yield in Europe, and of a production in this country of at least 100,000,000 bushels more than the product of 1885; and therefore, on the basis of present conditions, a probable full supply of the wants of the world for the coming year.

It finds that there has been some increase of wheat area even in Europe, and very material enlargement of breadth in the United States, some in India, Australasia, and South America, which causes a full supply, if not a plethora, in the markets of the world, and which has reduced the price in Liverpool to a lower point than has been recorded in 125 years.

It shows the fact, which those who only look at the commercial movement often fail to see, that nearly all the wheat-raising countries of the world aim to produce a full supply, and usually succeed; that North America, South America, Asia, Africa, and Australasia each produce a supply, and generally some surplus, while Europe produces $3\frac{1}{2}$ of the 4 bushels required per capita, besides another half bushel for seed, say about 165,000,000 bushels. It shows that if Great Britain shall be set off from Europe, the Continent will supply itself usually, or at least require only a few million bushels after its interior distribution is effected. In other words, the world is striving to deluge Liverpool with wheat, and finds elsewhere, and is likely to find elsewhere, despite any law except the natural laws of production and self-preservation, no markets that are worth striving for, or that can enrich any wheat-growing nation.

The report of the Statistician is given in full.

1.—(*a*) STOCKS ON HAND.

In "stocks on hand" are included the estimated amount in the hands of farmers and the "visible supply" of commercial authorities, but not that of unenumerated wayside granaries, the unmanufactured stocks of millers, or the manufactured product on its movement from mill to mouth.

Wheat stocks, May 1.

Years.	Stocks.			Previous crop.
	Farmers'.	Commercial.	Aggregate.	
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*
1886	60,000,000	44,000,000	104,000,000	357,000,000
1885	112,000,000	40,000,000	152,000,000	513,000,000
1884	73,000,000	22,000,000	95,000,000	421,000,000
1883	91,000,000	20,000,000	111,000,000	504,000,000
1882	66,000,000	10,000,000	76,000,000	383,000,000

Were the mill stocks, unenumerated commercial grain in obscure storage, and manufactured wheat in distribution included in the above aggregate the addition might suffice for the consumption of two months. This portion of the visible supply will be greatly reduced before the 1st of September, and will swell the above aggregate of stocks for the year's consumption. Then the harvest will be in progress in Texas during the present month, in Tennessee in June, in the Ohio Valley the 1st of July, and in Michigan later in the same

month. While the new crop is slow in its commercial movement at first, consumption in farming neighborhoods commences at once. There is a record in Northwestern Indiana of "grinding new wheat night and day on July 5," and similar records are not infrequent. Were the supply for milling exhausted two months before the 1st of September, there would be no difficulty in obtaining a sufficiency from the new crop. Last year the harvest not only prevented depletion of commercial stocks, but added several million bushels in July and August. These sources of supply in the later months of the harvest year are larger than consumers and commercial dealers are apt to suppose, and as regards wheat, August 1 would more nearly mark the commencement of the new year.

The farmers' reserves are mainly in Michigan, Wisconsin, Minnesota, Iowa, Nebraska, and Dakota.

The commercial stocks are as follows:

	Wheat.	Corn.
	Bushels.	*Bushels.*
New York	4,138,095	2,251,834
Philadelphia	492,635	124,314
Baltimore	459,458	499,191
Buffalo	2,480,117	8,200
Toledo	1,743,604	478,438
Detroit	1,597,902	56,223
Chicago	11,777,804	4,019,471
Milwaukee	3,335,030	556
Saint Paul	1,008,000	....
Minneapolis	4,707,999	....
Duluth	7,393,748	....
Saint Louis	997,169	2,055,547
Kansas City	446,135	161,140
Other points	1,703,911	822,434
On lakes	2,268,353	3,111,263
Total 1886	44,549,960	13,588,611
Total 1885	40,451,148	9,121,508
Total 1884	22,464,776	13,601,309
Total 1883	20,731,911	16,894,226
Total 1882	10,577,543	8,407,247

(*b*) REQUIREMENTS TO SEPTEMBER 1.

The natural requirements for consumption and the actual exports (including flour as wheat) are as follows:

Years.	Consumption.	Exportation.	Aggregate.
	Bushels.	*Bushels.*	*Bushels.*
1886	84,000,000	51,000,000	135,000,000
1885	82,000,000	27,000,000	109,000,000
1884	80,000,000	42,000,000	122,000,000
1883	81,000,000	31,000,000	112,000,000
1882	79,000,000	51,000,000	130,000,000

The wheat exportation, in this statement is largely taken from the new crop in July and August, complicating the exhibit which the resolution requires, and accounting for the apparent (but not real) trenching upon the stocks reported above. For instance, in 1882,

after the short crop of 1881, the exports of July and August were nearly three times as much as those of May and June.

Months.	Wheat.	Flour.	Total.
	Bushels.	*Barrels.*	*Bushels.*
May	5,336,253	434,144	7,289,901
June	4,406,370	474,025	6,533,482
July	10,484,546	492,226	12,699,563
August	20,900,223	695,525	24,030,085
Total	41,127,392	2,095,920	50,559,031

More than half of this exportation was from the new crop, and at least an equal amount went into home consumption, to eke out old crop deficiency.

The following table gives the production and distribution of five years, showing the year's consumption and actual exports, and a difference of 14,000,000 bushels for other use than as food, loss or waste, or surplus:

Years.	Production.	For food.	For seed	Exportation.	Total distribution.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
1881	383,280,090	235,249,812	55,215,573	121,892,389	412,357,774
1882	504,185,470	255,500,000	52,770,312	147,811,316	456,081,628
1883	421,086,160	259,500,000	54,683,389	111,534,182	425,717,571
1884	512,763,900	265,000,000	55,266,239	132,570,367	452,836,606
1885	357,112,000	271,000,000	51,474,906	94,565,794	417,040,700
Total	2,178,427,620	1,286,249,812	269,410,419	608,374,048	2,164,034,279
Average	435,685,524	257,249,962	53,882,084	121,674,810	432,806,856

This would indicate that the surplus on September 1, with average receipts from the new crop, will exceed that of 1881, when the visible or commercial supply was about 20,000,000 and the invisible probably a full average.

CORN.

The visible stocks of corn are given with those of wheat. The requirements of four months to September 1 in any year are a very flexible factor in crop consumption, which is itself so variable, ranging from 1,200,000,000 to 1,800,000,000 bushels, with bad and good crops. There are so many partial substitutes for corn as a stock-feeding material that there can be no fixed or absolute requirement for a given period. The crop of recent years, the stock remaining March 1, and the exportation of the year are sufficient indications of comparative supply during the period:

Year.	Crop.	Stock March 1.	Exportation.
	Bushels.	*Bushels.*	*Bushels.*
1882-'83	1,617,000,000	587,000,000	42,000,000
1883-'84	1,551,000,000	512,000,000	46,000,000
1884-'85	1,795,000,000	675,000,000	53,000,000
1885-'86	1,936,000,000	773,000,000	65,000,000

2.—PRESENT ACREAGE.

The estimated acreage of winter wheat now growing, and of spring wheat sown, or to be sown (the latter from data not sufficiently full on the 1st of May to determine with precision), in comparison with the area harvested in four preceding seasons, is as follows:

Year.	Winter.	Spring.	Total.
	Acres.	*Acres.*	*Acres.*
1886	24,727,087	11,800,000	36,527,087
1885	22,148,543	12,040,703	34,189,246
1884	28,345,708	11,130,177	39,475,885
1883	26,411,928	10,043,665	36,455,593
1882	27,477,230	9,589,964	37,067,194

The estimate for spring wheat of the present year is obviously subject to revision, as the sowing was not entirely completed on the 1st of May. Dakota is assumed to have five-sixths of its proposed area (2,400,000 acres) seeded at that date. Minnesota reports indicate some decrease of area.

The acres of former years are those harvested. In 1883, and very notably in 1885, the acreage seeded was larger than the figures above, being reduced by extensive substitution of other crops for wheat destroyed by the freezing and thawing.

The requirements of present consumption will be met by a breadth of 27,000,000 acres with an average yield, leaving about 9,500,000 acres for the production of wheat for export; sufficient to produce, with an average yield, 114,000,000 bushels. A large yield like that of 1884 would allow 150,000,000 bushels for exportation.

3.—(*a*) FOREIGN PRODUCTION.

The requirements of European demand can be better indicated by a statement of the average production and consumption for a period of years, in connection with the latest facts of product and supply. A collection of the facts of production between 1874 and 1881, so far as obtained for consecutive years, makes the average production of Europe 1,144,000,000 bushels; the consumption, in food and seed, 1,312,000,000 bushels, requiring a supply from other continents of 168,000,000 bushels.

The rate of European consumption, though varying from a single bushel in Norway to 9 in France, averaged (very nearly) 4 bushels per capita, or 3½ bushels exclusive of seed.

The rate of yield in the last five years has been larger than for eight years preceding, upon a somewhat larger area; so that the average product, as shown by a collection of data more nearly complete than is often presented in similar statements, makes an aggregate production of 1,210,000,000 bushels; an increase of about 66,000,000 bushels. There is a small increase of population and some advance in rate of consumption, yet some portion of the former European deficiency is provided for at home, reducing the quantity to be obtained from America and elsewhere, and also aiding slightly in the reduction of the price of wheat throughout the world.

The following table gives, as far as possible, the official returns of the product of the last five years in all the countries of Europe, and

is corrected, as far as possible, by official returns received since this matter was prepared, modifying slightly the figures for 1885 and the average. It shows that 1881 and 1883 were years of average yield, those of 1882 and 1884 seasons of large, and that of 1885 one somewhat above the medium production. The average of all is 1,210,000,000 bushels.

Production of wheat in Europe from 1881 *to* 1885, *inclusive.*

Countries.	1885.	1884.	1883.	1882.	1881.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Austria	48,281,992	43,814,746	37,871,261	44,548,149	41,167,716
Hungary	113,805,460	107,208,499	90,541,782	131,746,879	88,889,962
Belgium	19,573,926	22,700,000	16,645,666	24,990,030	14,782,229
Denmark	5,000,000	4,969,739	4,682,130	4,554,284	3,102,923
France	311,733,033	324,130,397	294,400,346	346,610,624	274,699,385
Germany	95,505,881	91,082,424	86,379,000	93,823,048	75,660,351
Great Britan and Ireland	82,081,382	84,595,368	72,768,921	91,381,503	82,635,679
Greece	5,102,894	*5,102,894	*5,102,894	*5,102,894	*5,102,894
Italy	118,244,589	115,500,000	124,411,748	155,012,168	100,708,461
Netherlands	4,965,625	5,892,079	5,628,643	5,439,488	4,704,575
Portugal	7,661,250	7,093,780	8,512,500	7,200,000	9,000,000
Roumania	22,629,063	36,887,000	20,000,000	30,000,000	25,000,000
Russia †	177,929,544	266,711,972	218,816,360	202,907,736	265,131,340
Servia	4,681,875	6,242,500	4,500,000	6,810,768	*4,256,730
Spain	113,500,000	99,312,500	120,000,000	85,134,600	*119,188,440
Sweden	3,916,601	3,822,857	3,107,304	3,792,884	2,222,845
Switzerland	2,057,188	*2,128,125	*2,128,125	*2,128,125	*2,128,125
Turkey	45,400,000	42,562,500	36,887,500	*40,867,200	*40,867,200
Other countries	*567,500	*567,500	*567,500	*567,500	*567,500
Total	1,182,637,753	1,270,324,880	1,152,951,680	1,282,617,880	1,159,816,355

* In the absence of official or reliable statistics for this year an average product is given.
† Exclusive of the Vistula Governments.

This statement shows that the average production of Europe during the past five years has been increased some 50,000,000 bushels over the average of the ten years preceding, which included several seasons of unusually low yield in Western Europe. Those exceptional years were the ones in which American exportation ran abnormally high, and that extraordinary demand led to an increase of millions of acres of wheat in this country, and to further enlargement of area in Russia, India, Australia, and South America. This furnishes a sufficient explanation of the present plethora and low prices.

The crop of 1885 in Europe was nearly equal to the average of five years, while the one preceding was much larger in Europe and in America. The average production of the last five years in the United States was 436,000,000 bushels; of the ten years preceding, some of which supplied the heaviest demand for exportation ever known, 338,000,000 bushels. Thus the increase is at least 148,000,000 bushels, while the increased population from 1875 to 1883 (say 18,000,000 in Europe and 10,000,000 in the United States) would demand nearly that quantity. It is not true, then, that the comparative supply is less than formerly from the home product of these great producing countries. And the increase in other quarters, in Canada, Mexico, India, South America, and North Africa is probably an average of 7,000,000 acres, with an average increase of product of 63,000,000 bushels, two-thirds of which is available to enlarge the commercial supply. This explains why our exports have averaged 122,000,000 bushels for the last five years, when for the three years preceding the average was 171,000,000 bushels.

The product of the world for 1885–'86, harvested in 1885 in the

northern hemisphere and in the early months of 1886 in the southern, may be stated as follows:

	Bushels.
Europe	1,184,000,000
North America	409,000,000
South America	25,000,000
India	287,000,000
Australasia	37,000,000
Africa and Western Asia	134,000,000
Total	2,076,000,000

The product of Algeria, Egypt, Asia Minor, Persia, and other districts included in Africa and Western Asia, is stated on commercial authority, and cannot be vouched for as accurate. Most of the other estimates which make the aggregates of this statement are official. The grand aggregate of 2,076,000,000 bushels does not represent absolutely the whole production of the world, as China and Asiatic Russia are not considered (the latter credited with only four or five million bushels), as the quantity is uncertain and has no bearing upon the commercial supply of Europe.

(b) COMMERCIAL SUPPLY.

The ordinary method of forecasting demand by an exhibit of commercial stocks is unreliable, if not misleading. A large accumulation of stocks may be strong presumptive evidence of large crops, yet the visible supply is not necessarily in proportion to the invisible; nor are the commercial sales of a period an infallible measure of the actual consumption of that period. For instance, the receipts of foreign and native wheat in the markets of Great Britain for thirty-six weeks up to May 1, 1886, were 72,149,660 cwts. against 84,805,000 cwts. to May, 1885; and to May 1, 1884, they were 76,230,000 cwts. against 87,970,000 cwts. for a similar period of the previous year. The crops of the world for 1882 and 1884, as shown above, were very large, and the market movement of these years was heavy, but the invisible remainder was larger proportionally than the visible supply, and contributed to a reduction of prices in succeeding years, while the fullness of visible stocks of those years limited the demand for consumption in the seasons following.

In view of these considerations, it has been deemed best to ascertain the actual production of the world and the normal consumption of the principal consuming countries, to afford an indication of the real supplies available, both in the hands of producers and in the world's markets. The absurdity of reliance on stocks alone is shown by the fact that the average stocks of Great Britain on the 1st of April for six years past have not been equal to three weeks' consumption, and they have sometimes been largest when taken from a medium crop.

The statement of production above shows that the year 1884 was one of large yield everywhere, and that 1885 had an average product in Europe, a large yield in India and Australia, and a small crop in the United States. The following table gives in round numbers the pro-

duct of 1885 (without reference to surplus of previous years) and normal requirement for consumption:

Countries.	Crop 1885.	Consumption.	Surplus.	Deficiency.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*
Austria-Hungary	162,000,000	144,000,000	18,000,000	....
Belgium	20,000,000	38,000,000	....	18,000,000
Denmark	5,000,000	3,000,000	2,000,000	....
France	312,000,000	343,000,000	....	31,000,000
Germany	96,000,000	117,000,000	....	21,000,000
Great Britain	82,000,000	225,000,000	....	143,000,000
Greece	5,000,000	10,000,000	....	5,000,000
Italy	118,000,000	136,000,000	....	18,000,000
Netherlands	5,000,000	12,000,000	....	7,000,000
Portugal	8,000,000	9,000,000	....	1,000,000
Roumania	23,000,000	18,000,000	5,000,000	....
Russia	178,000,000	144,000,000	34,000,000	....
Servia	5,000,000	3,000,000	2,000,000	....
Spain	114,000,000	114,000,000	....	....
Sweden	4,000,000	5,000,000	....	1,000,000
Switzerland	2,000,000	11,000,000	....	9,000,000
Turkey	45,000,000	40,000,000	5,000,000	....
Total	1,184,000,000	1,372,000,000	66,000,000	254,000,000

The summary of product of 1885 and net consumption of 1885–'86 is thus stated:

Geographical division.	Crop.	Consumption.
	Bushels.	*Bushels.*
Europe	1,184,000,000	1,372,000,000
North America	409,000,000	364,000,000
South America	25,000,000	23,000,000
India	287,000,000	240,000,000
Australasia	37,000,000	20,000,000
Africa and West Asia	134,000,000	125,000,000
Tropical islands	....	21,000,000
Total	2,076,000,000	2,165,000,000

With medium to large yields in nearly all countries in the world, the United States excepted, the apparent deficiency of production is only 89,000,000 bushels, while in 1884 the excess over this requirement of consumption was at least 125,000,000 bushels.

4.—EUROPEAN STOCKS ON HAND.

The stocks on hand in Great Britain of both wheat and corn April 1, for the last five years, have been as follows (in Liverpool, London, Fleetwood, Gloucester, Bristol, Hull, Newcastle, West Hartlepool, Glasgow, and Dublin), calculated in Winchester bushels:

Years.	Wheat.	Corn.
1886	14,146,265	1,061,228
1885	8,164,794	1,060,254
1884	17,031,889	1,654,377
1883	10,310,975	1,375,742
1882	7,950,065	1,218,885

Stocks in Paris at the same date in 1886 slightly exceeded 3,000,000 bushels. They were about 3,000,000 bushels April 1, 1885, and nearly 5,000,000 bushels April 1, 1884.

Records of other continental markets are not complete, but stocks are generally small and differ little in quantity from those of a year ago.

There are no great reservoirs of stored wheat in these hand-to-mouth markets. Stocks represent the consumption of a fraction of a month, hence a statement of stocks on hand, except in the United States, is of little utility. In Russia and Southeastern Europe the reserves are invisible, and in good years the distribution is much slower than in this country, and liable to go over to succeeding crops.

The amount on the water from all parts of the world is a somewhat larger consideration. The British trade records, May 1, made in round numbers the quantity of wheat and flour "on passage" 17,000,000 bushels against 25,000,000 bushels at the same time last year. French calculations made the total coming to Europe 21,000,000 bushels against 30,000,000 bushels last year.

Comparing stocks on hand (greater in Great Britain), in connection with grain and flour en route by sea, there appears to be a small decline, but not exceeding a few million bushels, perhaps not exceeding two days' consumption of Europe, in comparison with the stocks of last year.

In the first months of 1886, to May 1, the importation into Great Britain has fallen off one-third, or 15,000,000 bushels, as compared with the same months in 1885. With this reduction, the proportion contributed by the United States amounts to 16,000,000 bushels, including flour as wheat, or 52 per cent. of British imports. India, in these four months, sent over 11,000,000 bushels, and Russia nearly 5,000,000 bushels. A comparison of the four months of 1885 and 1886, to April 30, is as follows:

From—	1885.	1886.
	Bushels.	*Bushels.*
Russia	3,591,101	2,579,696
Germany	990,138	1,345,364
Turkey	258,600	148,988
Roumania	66,302	134,417
Egypt	143,655	....
United States:		
Atlantic	9,118,404	3,887,191
Pacific	10,318,601	5,639,349
Chili	90,569	296,804
British India	4,787,507	6,577,751
Australasia	1,480,530	357,118
British North America	63,902	59,324
Other countries	689,972	753,275
Total	31,599,281	21,779,277
Flour as wheat	14,373,226	8,825,334
Grand total	45,972,507	30,604,611

While the importations of 1885 gave an excess over consumption of about 10,000,000 bushels, there is a deficiency since January that more than overbalances it.

5.—THE COMING CROPS.

(a) WHEAT.

The supply of the commercial year 1886-'87 is to come from the crops already harvested in the southern hemisphere and in India, and those to be harvested during the next four months. The crop of India, grown on an area reduced about one and three-fourths million acres, may have yielded 265,000,000 bushels. The Australasian crops are greatly reduced, and from present information will not exceed 22,000,000 bushels. Those of South America are somewhat larger than last year, how much is not yet known, but are not likely to increase the product more than 5,000,000 bushels. From present information it is fair to estimate a decrease of 32,000,000 bushels from the aggregate of last year's production in the districts already harvested.

The harvests of the northern hemisphere, in progress from the present time to October, between 30° and 60° north latitude, but mostly in July and August, cannot now be foretold. With a continuance of present conditions the product of winter wheat will exceed an average and produce nearly or quite 13 bushels per acre; and with spring wheat, on an area equal to the breadth of last year and average condition of growth, a total product of about 465,000,000 bushels should be expected. This would give a crop of 108,000,000 bushels larger than that of last year.

In Europe, the area of wheat in Great Britain has been reduced 8 to 10 per cent., which means only 7,000,000 or 8,000,000 bushels at best. In France the breadth is apparently as large as that of last year. There is no indication of any material change in the acreage of Europe, which will probably be about 94,000,000 acres, and prospects are good up to the present date for a product equal to that of last year—1,184,000,000 bushels—though the course of the season may yet cause a variation of 50,000,000 bushels above or below this figure. The present average yield of Europe, as a whole, is only about 13 bushels per acre, while that of the United States exceeds 12 bushels.

It is a mistake to assume that the breadth of wheat of Europe has recently been declining. There has been a marked increase in Russia, as in this country, in India, Australia, and South America. There has been some increase in Hungary, Germany, and France since 1880. The acreage of the following countries is given for five consecutive years:

Countries.	1885.	1884.	1883.	1882.	1881.
Austria	2,326,115	2,735,597	2,610,963	2,511,308	2,455,276
Hungary	6,773,899	6,795,019	6,435,528	6,161,272	6,260,558
France	17,220,552	17,426,038	16,812,242	17,069,154	17,195,971
Germany	5,000,000	4,741,730	4,744,747	4,498,826	4,488,995
Great Britain and Ireland	2,553,092	2,750,588	2,713,282	3,163,899	2,967,059
Netherlands	205,000	219,193	214,040	229,491	219,200
Total	34,078,658	34,668,165	33,530,802	33,633,950	33,587,059

The averages of yield in these countries range from 15 bushels in Austria-Hungary to 28 in Great Britain, and the average of all for five years is nearly 19 bushels. Russia has an area of nearly 31,000,000 acres, and yields scarcely 8 bushels per acre. Other countries have an aggregate of about 29,000,000 acres, and produce an average of 11 or 12 bushels per acre.

The area planted in wheat, and now harvested or growing, is probably very nearly as follows:

	Acres.
Europe	94,000,000
North America	40,500,000
South America	6,000,000
India	26,000,000
Australasia	3,500,000
Africa and Western Asia	13,000,000
Total	183,000,000

The average yield of the world is a fraction above 12 bushels per acre, and the good and bad seasons, irregularly distributed geographically, equalize production in a large measure, so that the yearly average rarely rises or falls half a bushel from the normal average for a period.

(b) CORN.

As this country now produces three-fourths of the corn of the world, and has averaged for five years a product of 1,619,000,000 bushels, and exported only an average of 56,000,000 bushels, or 3½ per cent., and would readily have doubled the exportation without missing it, it appears almost frivolous to give stocks in the commercial markets which rarely show more than 1 per cent. of the production at one time. The stocks in this country and Europe, however, are found above in connection with wheat.

The principal buyer of maize is Great Britain, and in the last five years the purchases have averaged 58,000,000 bushels per annum, of which this country has contributed 36,000,000 bushels, or 62 per cent. of all, without counting that going through Canada. Roumania, Russia, Turkey, and Egypt always furnish a small amount.

Except in this country and Mexico maize is a minor product, and is produced in countries which are not generally advanced in crop-reporting methods. It is somewhat difficult to give the exact status of acreage and product, but the following table is the best attainable approximation. It is for the year 1885, except as indicated by notes, for certain countries making only occasional returns of production.

Countries.	Acres.	Bushels.
United States	73,130,150	1,936,176,00
Canada	200,000	6,000,00
Mexico	10,600,000	213,000,00
Russia *	11,361,000	70,224,00
Roumania †	4,423,000	43,000,00
Austria-Hungary ‡	5,458,757	105,640,81
Italy §	4,240,261	75,645,85
France ‡	1,523,787	27,689,97
Spain ‖	2,300,000	37,378,38
Portugal ¶	1,284,960	20,288,12
Total	114,521,915	2,535,043,15

*Average acres of 1870 to 1879; product 1879.
†Average production; acreage 1881.
‡1884.
§1883.
‖Average product; estimated acreage.
¶Average product (Neumann-Spallart).

There is a small area of maize in several countries of South Amer ica, and a little grown in the more northern portions of German and in some unenumerated districts of Southeastern Europe, in Al

geria, Egypt, Australia, and at the Cape of Good Hope. In round numbers the present area of maize may be stated approximately at 120,000,000 acres, and the product at 2,600,000,000 bushels, making an average product of about 22 bushels per acre.

DEBTS OF FARMERS.

There are now about 5,000,000 owners of farms. A million of new farms have been acquired since 1880. Many of the 4,000,000 then in cultivation have since changed hands. Hundreds of thousands of these are owned by young men and others who never before tilled lands of their own, and who commenced husbandry with small means, little more than health, energy, and determination to succeed. Necessarily indebtedness has been incurred in many of these cases, in purchasing old farms, in stocking farms already paid for, or in fencing and building upon lands obtained from the Government under the homestead act. To such as commenced judiciously, with a full knowledge of the responsibilities involved, and with will and industry commensurate with the burden assumed, a mortgage may prove a blessing. It represents capital, without which the business of farming cannot be undertaken or its products and profits be secured. It enables a poor but capable and industrious young man to secure a home and a profitable business, paying for it in easy installments; but it becomes a withering curse when it makes production dear and difficult, consumes a crop before it is made, and renders indebtedness hopeless.

The system of advances by merchants or brokers upon growing crops is especially dangerous and disastrous. It is not usually a prevalent practice, except in districts where a single crop dominates rural industry and brings ready money at any time, rendering borrowing easy and encouraging the habit of spending before earning. It has been prevalent from time immemorial—at least for forty years from personal knowledge of the writer—in the cotton States.

No product of agriculture is more surely a money crop in any part of the world than cotton, and none more promptly traverses the ways of commerce. It has therefore become (with perhaps one principal associate—maize) almost the sole product of large districts of country, rendering necessary the purchase abroad of supplies of all kinds, agricultural and industrial, and their original cost, long-distance transportation, and wholesale and retail profits render them exceedingly expensive. It is selling the cheapest cotton in the world and buying all supplies at enormous prices—a practice with which only fertile lands, abundant crops, and persistent industry can save from bankruptcy.

It is a matter of congratulation that the burden of debt is decreasing, and is in fact relatively less than it was ten years ago. An investigation made by State statistical agents, undertaken to show the actual and comparative condition of farmers as to indebtedness, affords evidence of gradual amelioration, decrease in number and amount of farm mortgages, and in advances by merchants in those regions where such practice prevails. The inquiry was first made in the cotton States; afterwards in the Ohio Valley, and in New York and Pennsylvania. In the Eastern States, where no such inquiry has yet been instituted, the farmers are not burdened very much with debt, while many of the more prosperous hold mortgages on farms of the distant West and other farms of Western property. In the newer States west of

the Mississippi there is far more general indebtedness than in the central district east of that river. Further investigation in that region and on the Pacific coast is contemplated.

To give a better idea of the state of farm-making and land development in the States reported on the following table is presented, showing the number and size of farms, amount of land held, and proportion unimproved, according to the last census, in the States included in these investigations:

States.	Number of farms.		Land in farms.		Average size of farms.		Per cent. unimproved.	
	1880.	1860.	1880.	1860.	1880.	1860.	1880.	1860.
			Acres.	*Acres.*	*Acres.*	*Acres.*		
New York	241,058	196,990	23,780,754	20,974,958	99	106	25.5	31.5
Pennsylvania	213,542	156,357	19,791,341	17,012,140	93	109	32.2	38.5
Ohio	247,189	179,889	24,529,226	20,472,141	99	114	26.3	38.3
Michigan	154,008	62,422	13,807,240	7,030,834	90	113	39.9	50.5
Kentucky	166,453	90,814	21,495,240	19,163,261	129	211	50.1	60.1
Indiana	194,013	131,826	20,420,983	16,388,292	105	124	31.8	49.7
Illinois	255,741	143,310	31,673,645	20,911,989	124	146	17.5	32.6
Missouri	215,575	92,792	27,879,276	19,984,810	129	215	39.9	68.7
Kansas	138,561	10,400	21,417,468	1,778,400	155	171	49.9	77.2
Nebraska	63,387	2,789	9,944,826	631,214	157	226	44.6	81.2
North Carolina	157,609	75,203	22,363,558	23,762,969	142	316	71.0	72.6
South Carolina	93,864	33,171	13,457,613	16,195,919	143	488	69.3	71.8
Florida	23,438	6,568	3,297,324	2,920,228	141	444	71.3	77.6
Alabama	135,864	55,128	18,855,334	19,104,545	139	346	66.2	66.6
Mississippi	101,772	42,840	15,855,462	15,839,684	156	370	67.1	68.0
Louisiana	48,292	17,328	8,273,506	9,298,576	171	536	66.9	70.9
Texas	174,184	42,891	36,292,219	25,344,028	208	591	65.1	89.5
Arkansas	94,433	39,004	12,061,547	9,573,706	128	245	70.2	79.3

The points of greatest significance in this table are the small proportion of unimproved land in the Ohio Valley, less than three-tenths of the area, and the great reduction in size of farms in the cotton States and increase of their number. The latter fact is due largely to the renting of old estates on shares or otherwise to several tenants who report separately, making the number of farms far more than the number of proprietors. There is no immediate prospect of a change of this system, though the individual tenants hold by a very uncertain tenure. The tendency will, doubtless, still be strong towards subdivision of lands, both by sale and rent.

NEW YORK.

The result of the investigation in New York shows that three-tenths of the farms are mortgaged, and that one in twenty of the farm proprietors is hopelessly in debt, if the estimate, which is based upon extensive information, is reliable. The interest is ample, but not excessive, averaging, as is assumed, 5½ per cent., though the legal rate is 6 per cent. Mortgages ran to neighboring farmers and merchants and to insurance and trust companies. It is thought that one-tenth of the farm-owners are possessors of other forms of property. It is doubtless true, in many localities, that the value of such property is fully equal to the amount of indebtedness of less prosperous farmers. The State agent says:

In the best sections of the State the farmers are making money or holding their own, and are less in debt than ten years ago; while in the more unproductive parts, and those more easily affected by drought, there has been a considerable increase, so that on the whole farmers are more in debt than they were ten years ago, but the average indebtedness is not heavy. There are a large number of farms, which were

purchased a few years ago and mortgaged, which now would not sell for more than the face of the mortgages, owing to the depreciation of the farming lands, which on an average is fully 33 per cent. in ten years. Probably one-third of the farms in the State would not sell for more than the cost of the buildings and other improvements, owing to this shrinkage. Real estate in New York is burdened with an undue share of taxation, while personal property escapes almost entirely. The farmer pays the tax on the property represented or covered by the mortgage held by the capitalist, which is a great wrong. The average income from farms over and above expenses will not exceed 3½ per cent. on the capital invested. The wages for farm help have been for several years 33 per cent., more than the business could bear. In many instances the employés make all there is made on the farm. The current rate of wages asked by common farm help, by the day, for ten hours' service, at any time during the year, is $1, with board. The diversified farm industries in New York have prevented general disaster, and not more than 5 per cent. of the farmers are insolvent.

Thirty per cent. of the farms in the State are mortgaged, ranging from 2 per cent. of their value to 100 per cent.; average 66⅔ per cent. of estimated value. These securities are held by retired or more successful farmers, merchants, savings banks, and insurance companies. The latter, with long time and safe investments, will loan moneys with 3 and 4 per cent. The rate for the others is mostly from 5 to 6 per cent. In some instances, under the requirements of former contracts, the old legal rate of 7 per cent. is still paid. The average rate of interest is 5.5 per cent., which is ½ per cent. less than the now legal rate. Twenty per cent. of the farmers have property interests outside of their farms, mostly in the form of money deposited in savings banks, mortgages, and notes. It is natural for a farmer to invest his surpluses in lands, and not more than 5 per cent. have property as capital in other forms of business. No class of people labor more hours in a day than farmers, and none have the same opportunities for an independent, healthful, and happy life.

PENNSYLVANIA.

The indebtedness of farmers of Pennsylvania, it is believed, has decreased as compared with ten years ago. It is estimated that not more than 15 per cent. of the farms are mortgaged. The average interest rate is about 5 per cent. Many farmers have property in other branches of business and farmers themselves hold in part the indebtedness of other farmers. With an average value of farms, according to the last census, of almost $50 per acre—nearly $1,000,000,000, or about one-tenth of the farm valuation of the United States—owned mainly by the farmers cultivating them, and yielding a product worth $431 for each person engaged either as farmer or laborer in agriculture, the agricultural interest in Pennsylvania may be said to be prosperous, even in the present era of low prices. Of course there are some who occupy positions of hardship and difficulty. The source of this prosperity is found in the local markets of the State. It is probable that no other State is more nearly self-supporting, and perhaps none that depends on other States or other countries so little either in buying or selling products of agriculture. The State agent says:

It is extremely difficult to ascertain the pecuniary condition of the farmers of this State, for they are afraid that any statistical information they give will be used for purposes of taxation. The tax law passed two years ago required a statement, on oath, of all bonds, stocks, notes, and mortgages; and the amount of money so invested by farmers caused great surprise; yet there was a great deal of evasion and suppression, and no less than twelve counties failed to report any money at interest when the triennial assessment was made in 1885.

From Lawrence County I get the definite information that the condition of the farmers is worse than at any time since the war; and that there are $300,000 of mortgages and $150,000 of judgments against the farmers of that county. I find that the assessed value of the real estate outside of cities and boroughs is $10,159,069; and it is probably assessed at less than half its value; but supposing it to be assessed at its full value, the indebtedness in the two forms is less than 4½ per cent. of the value of the property. This is the worst report I have received.

Probably 25 per cent. of the farmers are in debt; but not more than 5 per cent. hopelessly so, or to a greater extent than their credits.

Probably 15 per cent. of farms are mortgaged, 50 per cent. of the debts being to other farmers or retired farmers, other heirs or legatees; and the remainder to bankers, merchants, insurance companies, and machine and agricultural-implement makers.

About one-third of the farmers have shares in incorporated companies, bonds of the State and United States Government, and of counties and municipalities, and of railroad and other companies, town lots, Western lands, notes, mortgages, and judgments.

The indebtedness of farmers has been incurred for, first, purchase money, in many instances one heir to an estate taking the farm and paying the others their shares. In other cases a farm passes, at the owner's death, into the hands of a person not related. Sales are also made by farmers desiring to move to some other State by those who wish to change their business, and by the sheriff. Second, for improvements on the farm, such as buildings, draining, and for improved live stock, and for improved implements.

KENTUCKY.

The farmers of Kentucky are attached to their homesteads, and hold their lands with considerable tenacity. There are fewer small farms than in neighboring States, the average being 129 against 99 in Ohio, and less subdivision and farm-making, consequently fewer beginners and borrowers on land security. It is estimated that scarcely more than one-eighth of the farms are mortgaged. The interest rate, however, appears to be high, as the average rate is estimated at 7 per cent., showing that money for investment is not very plenty. The investments of farmers in other property is not extensive, nor is there much capital obtained from other States for loans to farmers. The State agent says:

While for the last two or three years the farmers have made but little money, yet taking them throughout the State they may be said to be in a fairly good and healthy condition, and this in the face of the facts that the wheat crop before the last was almost a total failure, the last one, the best for years, ruling as low as from 68 to 70 cents per bushel; the tobacco crop not much more than quitting the cost of production, and the cattle-feeders realizing but small profits. The truth is, nothing in Kentucky has paid well but fancy horses and hemp and hogs in two or three years past. Notwithstanding, the farmers are not depressed, and are living on expectation of a brighter future. The chief indebtedness is to capitalists or money-loaners, or loan associations, of necessity. The Kentucky farmers are a frugal set, taken as a whole, and cut their garments according to the cloth. If crops fail, or there is a failure to realize expectations in prices, they cut down expenses as far as may be to meet the case.

I mention a fact that you may solve on any theory you choose. The bankers say they have more unemployed capital on hand at this time than for years before, at the same time of the year.

OHIO.

In this State a decrease of indebtedness during the past ten years is reported. It is estimated that one-fourth of the farms are encumbered by mortgages to secure debts to neighboring farmers and bankers, and to insurance companies and Eastern capitalists. The smaller debts are generally due on local loans. The rate of interest is averaged at 7 per cent. There are a few farmers who have capital employed in other business. Ohio farmers are generally in good condition, though feeling severely the disappointment of low prices of certain staple products. The following statement is an extract from report of the State agent:

While the indebtedness of Ohio farmers is no doubt very general, it is very evident from the county records that the amount of farm indebtedness is less than it was ten years ago, and would be still less if taxation were more nearly equalized in

the State. Everything possessed by the farmer is in sight for enumeration, and there is less evasion of taxation by the farmers than by any other class of citizens. The farmer, therefore, pays *his* full proportion of taxation and also a great portion that should be paid by speculators in stocks and mortgages and other personal and valuable effects, much of which is never returned for taxation. More equal taxation would enable the farmer to apply his excess, now paid, to a reduction of his indebtedness, and a few years, at most, would see him free and independent of debt.

The extent of farmers' property interests outside of farms is very limited. A few Ohio farmers have investments in Western lands and some in city property, but the surplus money of wealthy farmers rests, in many instances, in Government and other good securities. There are, however, but few such farmers; most of them have only surplus sufficient to keep farm matters moving along.

MICHIGAN.

The investigation as to indebtedness of Michigan farmers shows that it is neither very general nor heavy, yet probably a third of them are somewhat involved in debt, a few seriously. It is estimated that one-fourth of the farms are mortgaged for varying amounts, generally from one-fourth to one-half their value. It is an indebtedness largely due to other farmers, and in less degree to merchants and bankers. The average rate of interest may perhaps be placed at 7 per cent., though in some cases 6 suffices, while in the northern counties 8 or 10 is paid by many debtors. There are many farmers in the southern part of the State who possess surplus capital in the form of notes, mortgages, bank and railroad stocks, and interests in manufactures.

INDIANA.

Indebtedness of farmers is decreasing in Indiana, and it is estimated that 10 per cent. are in debt beyond the amount of their credits. Mortgages are divided in the following proportion, as estimated: To Eastern capitalists, 35 per cent.; to banks and manufacturers for machinery, 25; to secure payment of purchase money on land, 18; to school funds and local loaners of money, 22 per cent. It is estimated that farmers have property interests to the extent of one-fifth the value of farm property. The condition of Indiana farmers is therefore by no means serious. The State agent reports:

> The demand for loans is less now than at any time for a period of seven years; but the amount of mortgages on record shows but slight diminution. The average indebtedness, or the amounts for which mortgages are given by farmers, will average nearly $1,000. Although apparently there is less demand for large loans, and seemingly a better condition of money matters among farmers, yet there remains the fact that many of the farmers are victims of various swindling schemes, that have been so successfully worked in portions of this State (Bohemian oats, red-line wheat, &c.), and this class of indebtedness is much greater than the public are aware of. Yet another cause of distress among farmers is the inducement held out to them by agents of farm machinery of long time. Many are induced to buy, and are compelled to mortgage the farm to meet the notes when due. This cause has operated to produce 30 per cent. of all the mortgages on record against farms, but not over 25 per cent. of the amounts. I should think that 20 per cent. of the local capital is the property of farmers. This includes what may be invested in town property or local securities, manufactures, and gravel-road bonds.

ILLINOIS.

The proportion of unimproved land is less in Illinois than in any other State. Farms are gradually decreasing in size and increasing in number. In the establishment of new farms by young men and others without capital there are many that are encumbered by mort-

gages, large or small. These loans are held by Eastern capitalists, and by banks, manufacturers of farm machinery, and local loaners of money. The rate of interest may slightly exceed an average of 7 per cent. The State agent says:

With regard to the indebtedness of the farmers of the State there is a diversity of opinion. It may be safely asserted, however, that their indebtedness is not very general nor very heavy, and that it has gradually diminished within the last ten years. Probably 33 per cent. of the farmers are in debt. Much the largest part of their pecuniary obligations is for lands on which partial payments have been made on notes drawing from 6 to 8 per cent. interest per annum, and secured by mortgage on real estate. These mortgages are held mostly by Eastern capitalists, often by the representatives of large insurance companies. Loans of this kind are usually made for five years on lands at from one-third to two-thirds of their cash value, and are obtained through loan agents in different parts of the State, who charge a commission, making the cost to the borrower, including interest, from 6½ to 8 per cent. per annum.

There is still a larger class of debtors, which includes farmers of smaller means than those mentioned, and also renters or tenant farmers. Most of their debts are to banks and merchants, chiefly to the latter, for such supplies as are ordinarily needed in families. These obligations are met, according as the parties agree, in thirty, sixty, or ninety days—in some instances running six and even twelve months. This class of indebtedness is seldom allowed to go beyond the ability of the party making the purchase to pay. In case, however, of a failure to meet the payment when due, a chattel mortgage, or, in case of a tenant, a lien on his part of the crop, is given to the landlord, who assumes or pays the debt, or if not to the landlord, is given directly to the merchant himself. Recourse is seldom had to this mode of securing debts, as farmers as a rule so diversify their crops as to enable them to sell at almost any time something from the farm to meet these recurring demands. Advances are sometimes made by landlords to tenants, but never, we think, at a greater rate of interest than the legal rate, which is 8 per cent.

The tax laid upon the agricultural industries of the State (and for which the farmers themselves are most at fault) by the difference between the cash price and credit price for goods purchased of the merchants will probably equal 10 per cent.

The number of farmers having property interest outside of their farms we would not put higher than 3 per cent.; this would consist of bank stock, lands, town lots, within and outside the State, and live stock on the ranges of Texas, Wyoming, and Montana.

MISSOURI.

The State agent of the Department makes a report, which shows an average condition of indebtedness, with very little of the hopeless element in it and an existing tendency to improvement. These debts are mainly borrowed capital invested in lands and buildings and various improvements, enhancing the possible resources of productive industry. With discretion and diligence they may prove advantages. He says:

I regard the indebtedness as compared with other States or with other industries as not above an average. Compared with ten years ago but little change has occurred, but with a tendency to increase of indebtedness due to the last three years of decline in values. Up to three years ago reduction of debt was going on. I think that the tendency of late years has been towards the use of capital for improvements, although not to a sharp degree of change.

About 30 per cent. of our farmers are in debt above their credits, if mere annual store bills are excluded, and more if they are included. But such debts, while large in the aggregate, do not cut a serious figure with the average farmer; by no means so large as formerly and far behind the bad store system of debts of the South. Few farmers mortgage crops here to the trade, and not many trade on the credit of a coming harvest in a radical degree. Many run store accounts, but these are often offset by eggs, poultry, butter, corn, &c., from time to time delivered. Our traders not infrequently run accounts a year in such a style, the balance more often being against the farmer. This system enhances the cost of supplies above cash trades to some extent, but to no paralyzing degree.

About 20 to 25 per cent. of our farms are mortgaged. More of this indebtedness is due to other farmers than to any other class, while the balance is about equally

distributed between banks, merchants, and Eastern loan agents, and to miscellaneous sources. Our banks mainly loan upon names or indorsers.

The rates of interest vary widely. Heavy loans upon material amounts are secured from Eastern capital for from 6 to 7 per cent. The general rate is 8 per cent., but short and less desirable loans are often found at not less than from 9 to 10 per cent. The average rate will be over 8 per cent. and by may is rated as high as 9 per cent. Yet good property at ordinary length of time obtains money enough at 8 per cent. Our farmers have comparatively small investments outside of their occupation. Our State is young in many sections, and its farms are not yet all settled, and few have their equipments completed. Thus we have not ripened into that maturity where we need such outside investments. In fact, not capital enough is now used for the best results on our farms. But this is more the fault of judgment than the dictate of necessity, for we can secure the capital if desired. In short, our people are not in an impoverished condition nor under a heavier burden than they can well carry as a rule.

KANSAS.

The flood of immigration pouring over the entire area of this State, stimulated by rapid advance in real-estate values, the consequent demand for money in the purchase of land, erection of farm buildings, fence-building, prairie-breaking, and stocking with animals and implements, conduces to the demand for loans that is almost universal, and renders inevitable a large indebtedness. It is a wholesome indication that the process of liquidation from proceeds of labor in this laboratory of nature is progressing, and that the burden will be gradually lifted from Kansas farms. The agent says:

Indebtedness of farmers in Kansas, on the whole, is less in proportion than ten years ago, although it is much larger in the western or newer portion of the State. For the whole State it is still much larger than it ought to be.

Probably 20 per cent. of farmers are in debt beyond the amount of their credits. At least 50 per cent. of the farms are mortgaged, mostly to loan associations handling Eastern capital. Local bankers and capitalists are largely engaged in making real-estate loans.

The rates of interest charged on farm loans range from 6 to 10 per cent. On chattel loans the rates range from 10 to 18 per cent. Not more than 10 per cent. of farmers have property interests outside of their farms. The facilities for making real-estate loans in Kansas are very great. There is scarcely a town of 500 inhabitants that is not supplied with an agency for Eastern capitalists. The rates of interest are lowering each year under the competition.

NEBRASKA.

The secretary of the Nebraska board of agriculture makes a very favorable report of the financial condition of the farmers of that State. He estimates that the value of rural indebtedness has been reduced one-half in ten years. The rate of interest is 6 per cent., and by contract may be as high as 10. The proportion of farms mortgaged is quite small, the loans generally made by institutions known as loan banks. Farmers have some real and personal property interests, in town and country, not connected with agriculture.

NORTH CAROLINA.

In North Carolina the legal rate of interest is 6 per cent., but 8 may be charged upon agreement in writing. Yet this minimum charge is easily and largely exceeded. When the planter needs assistance from the merchant, the latter agrees to advance the supplies to a certain amount, taking a mortgage on the coming crop, payable when the crop matures. He then charges the farmer his own figures for supplies, from 15 to 25 per cent. more than cash price, thus compell-

ing him to pay a heavy interest, perhaps without realizing the fact that he is paying interest at all.

It is the opinion of the agent that the real interest, part of which is deducted in advance for cash and supplies furnished, is not less than 25 per cent., and that one-fourth of the cotton crop is sacrificed to meet the interest arising from this indebtedness.

SOUTH CAROLINA.

A similar investigation in South Carolina showed that the recorded liens for supplies, fertilizers, and money advanced amounted in 1882 to $9,218,312, and in 1885 to $6,595,000. Other indebtedness is assumed to amount to 30 per cent. more. The entire advances of 1882 are estimated at $12,000,000, and those of 1885 at $8,500,000. It is gratifying to know that planters were better supplied with home-grown products last year than ever before. It is thought that there was a material reduction in the advances in 1886. The most exorbitant prices are charged for goods advanced—20 to 40 per cent., and even higher charges. The planters bind themselves to consign their crops for sale to the factors making advances. The agent estimates that one-fourth of the cotton crop is pledged in advance.

GEORGIA.

The Georgia investigator reports bacon, lard, flour, corn, hay, and fertilizers as the principal supplies bought on credit. Corn worth 76 cents cash is charged 99 cents, payable November 1; bacon worth 8 cents is charged 10.5 cents; and 50 per cent is given as a reasonable average of the profits charged. Past-due indebtedness is carried over at varying rates, but at least 10 per cent. per annum, though only 7 or 8, if so stated in writing, is all that can legally be collected. The average rate of loans by banks to farmers is estimated at 15 per cent., ranging from 10 to 25 per cent. The amount of indebtedness is thought to be less than for any previous time in the last five years.

FLORIDA.

In Florida the average rate of interest paid by farmers is estimated at 16 per cent., varying from 10 to 24 per cent. The absence of restrictions upon usury "has brought into the State a class of unscrupulous money-lenders, who have pressed their loans upon the imprudent, and have secured themselves by bonds and mortgages upon real estate far below the true valuations, and in many cases these will be forfeited." Expectation of extraordinary gains has thus induced many to engage in mercantile pursuits on borrowed capital, until the business is overdone. Indebtedness is large in Florida, but no definite estimate is made. It is gratifying to know that the practice of borrowing money on crops is declining as variety in production is secured, and cotton becomes less prominent.

ALABAMA.

It is estimated in the Alabama investigation that 45 per cent. of he farmers of the State, white and colored, were in debt at the beginning of the year, without available means of liquidation; and that not less than 65 per cent. find it necessary to seek assistance from com-

mission or country merchants for supplies of some kind necessary in the progress of crop-making. The agent says:

The cost of this indebtedness, or the tax upon agriculture resulting from it, is found in such a multitude of ramifications that it is difficult to conceive of any respect in which agriculture is not crippled by it. It prevents the farmer from conducting his business upon the only absolutely safe and profitable basis—cash. Unable to purchase first-class stock and improved labor-saving implements, he does his work in the most costly manner. Compelled to purchase on time his supplies, &c., he pays not less than 50 per cent. more than the same goods would cost for cash. His energies are crippled; his independence destroyed. The cost of this indebtedness to the agriculture of the State in the form of diminished production and improvement and increased wear of farms and improvements is not less than $5,000,000 annually.

Where money is borrowed by mortgaging farms, either from those engaged especially in this business or by advances from commission merchants, the rate of interest ranges from 18 to 24 per cent. per annum.

The heaviest tax paid for advances is to local merchants who sell corn, bacon, &c., "on time," to be paid out of the cotton November 1. These advances usually commence March 1, and continue through September, some running seven months and some only one or two. The goods are usually sold "on time," at from 25 to 50 per cent. above the cash price, and, taking the average time at which the accounts run, the rate per annum would be upon all classes of goods purchased at the credit prices about 75 per cent. upon the cash price at which the same goods could be bought at the same place.

The tenants and croppers get about 35 per cent. of the cotton made in the State, and, as a rule, all of this is pledged for supplies before it is gathered. Certainly, taking the average, 90 per cent. of this is pledged. Out of the balance the plantation must be kept up and advances secured, in a majority of cases amounting on the whole crop of the State, according to the best information at command, to about 70 per cent. With the exception of the rates of interest, and rates on time purchases, these are, of course, merely estimates based upon the best information at my command.

MISSISSIPPI.

In Mississippi, according to the investigation made by the State agent, the interest rate, when supplies are furnished to farmers, is from 1 to 1½ per cent. per month, which is generally secured by mortgage. The bulk of the cotton crop generally goes to pay for supplies. About one-third of the farmers are out of debt; one-third are recoverably indebted; and one-third hopelessly ruined. The rate of interest on general indebtedness is usually 10 per cent. Those who are out of debt are common farmers, white laborers, who cultivate their own lands, and are in a prosperous condition. Those who buy mules, rent land, and have to be supplied with food generally come out minus at the end of the year, and they constitute a very large percentage of the labor force of the country. Unless farmers can get 10 cents per pound for cotton they can never keep out of debt. The ruling price paid to farmers in 1886 was 7 to 7½ cents per pound, which will not more than pay for the supplies in making the crop.

LOUISIANA.

It is estimated that 75 per cent. of the farmers of Louisiana are in debt to the extent of a fourth part of the value of the cotton crop.

The annual rate of interest upon advances of money and provisions is nominally 8 per cent., and 2½ per cent. for purchasing, 2½ per cent. for selling, and 2 per cent. freights. Total, about 15 per cent. Country merchants charge more, obtaining from 15 to 20 per cent. for advancing, besides a heavy profit on goods sold. The smaller farmers, who mostly live in the upland parishes, are more free from debt as a rule than the larger or more pretentious planters on our alluvial soils. The one-crop system and the purchase of supplies has

generally resulted in failure. Hence there is a growing disposition among them to plant more forage and food crops, making cotton and sugar of secondary importance. This is only retarded by their indebtedness to merchants, who demand from them yearly sufficient to cover their indebtedness. At present the planters are very much depressed, especially the rice and cotton men.

TEXAS.

It is thought that one-third of the Texas farmers are in debt, and that half require some advances from the merchant. It is a common practice for the farmer to arrange with the merchant for an advance of $2 to $5 per acre, generally $3 per acre, of cultivated land, to be secured by a crop lien.* The renter has greater difficulty than the owner in getting supplies; he must induce his landlord to waive his landlord's lien in the merchant's favor or to indorse the renter's note for such supplies. The crop lien is usually given for supplies rather than money. The annual rate of interest is 12 per cent., but the actual difference between cash and credit prices is 25 to 50 per cent. The western part of the State, engaged more fully in stock-raising, is in better condition than the eastern.

ARKANSAS.

The Arkansas agent estimates the proportion of farmers in debt in Arkansas at 75 per cent. in the cotton region and 25 per cent. in the grass and grain region. The interest rate is 6 per cent., with privilege, by agreement, of 10 per cent. The farms are not mortgaged as a rule. Indebtedness is of several kinds: To banks and money-lenders, for money or supplies furnished by farm owners to small tenants of large plantations; for supplies to small farmers or renters. The most numerous class requiring help is the tenant cultivating a few acres of cotton. The average increase of cost of all supplies by reason of these advances is estimated at 20 per cent. The report says of this class:

> The tenant or share-hand farmer: This man may or may not have a pony or mule. He rents land, say, for $6, $8, or $10 per acre, or works for part of the crop, but must have supplies from or through the landlord or by mortgaging his mule or pony and the crop he grows. Of course the risk on him is greater than any other class, and he must pay for the risk, and is scored at the rate of 50 to 100 per cent. I should say that this man, taking all things into consideration, on the average over the cash man, putting him at 100, pays 166, or two-thirds more than if he had money. This is the most numerous of all the classes, and comprises the bulk of the agricultural labor of the South.

This record makes a burden of interest that is unendurable. The estimate of North Carolina is 25 per cent., including the advanced prices of supplies furnished; of South Carolina, 15 per cent.; of Georgia, 50 per cent. in the prices of advances and 10 per cent. interest on past-due indebtedness; of Florida, 16 per cent.; of Alabama, 50 per cent. increase in price of goods and 20 per cent. on mortgages; of Mississippi, 15 per cent. on advances, without reference to increase of prices, and 10 per cent. on general indebtedness; of Louisana, 15 per cent., besides higher prices of goods and more for advances by

*Under the direction of the supreme court a mortgage is invalid given before the seed is in process of germination, and the general tenor of decisions of the courts is that a thing must be *in esse* before it can be disposed of in any way.

country merchants; of Texas, 12 per cent. nominal interest for supplies charged at excess of 25 to 50 per cent.; of Arkansas, 10 per cent. by contract on supplies charged an extra profit of 40 per cent. These are the averages assumed by our State agents as the cost of interest on advances secured by crop liens.

It appears that a large proportion of cotton planters are in debt for current supplies, and that the loss resulting amounts to $5,000,000 per annum in some States, and absorbs nearly or quite all the profits of production, while the soil is wearing away, with the lives of the cultivators, for the benefit of the commercial class.

CONCLUSIONS.

The facts developed indicate a considerable amount of indebtedness, diminishing from west to east and from south to north. It is gratifying to know that the burden is decreasing. The element of time in eliminating debts of pioneer settlement and improvement is obvious, for a large proportion of American farmers have settled with little capital, and have erected houses and barns, built fences, dug ditches, felled forests, or broken prairies by the labor of their own hands. The capital in agriculture is of recent creation; much the largest portion from the labor of a single generation of workers.

The inducement to improve and stock a farm on the basis of free land is sufficient to warrant incurring indebtedness on the security of youth and will and muscle; and the gradual reduction of the debt, while the property is increasing in value, is a surety of ultimate removal of the burden.

The worst form of indebtedness—advances upon growing crops, at exorbitant prices for goods supplied farmers for the accommodation, and high rates of interest—which has so long throttled industry and devoured the proceeds of labor in the cotton States, is gradually falling into disuse and should ultimately be discarded utterly. It is useless to hope for rural prosperity where the practice prevails. In such cases the borrower is literally a slave to the lender. In the older States the unagricultural property of farmers, in shares of banks and manufactures, notes, bonds and mortgages, and interests in minor local enterprises, is greater than the total indebtedness of the farming class. In most of the Central States, those of the Ohio Valley, this is also the case, where land is rising in value and wealth outside of agriculture is decreasing and absorbing the profits of farms and the proceeds of land sold by farmers who are contracting operations or retiring from active husbandry. In the remoter districts, where the pioneer is borrowing funds from distant capitalists, and the cotton grower is consuming his crop before it is grown, by the aid of the city broker, there may be less net capital in agriculture than the assessor shows.

On the whole the situation is hopeful, and the intrinsic wealth in agriculture slowly accumulating. The low prices of products are, indeed, discouraging, especially to those in debt. For the excessive decline in some of these the farmers are themselves to blame in not better adjusting production to consumption. Gradually there will come adjustment and a nearer approach to equality in values, and there will be less of hardship in the situation. Probably a reduction in wages of farm labor will be one of the movements in this adjustment, as wages are now higher than products. The tendency of the times is towards lower rates of wages in all kinds of industries of the

United States; a movement to be deprecated and delayed in the interest of a higher plane of culture and comfort for the working classes, if it cannot be wholly averted.

FRAUDS UPON FARMERS.

Dishonesty is not content, in these greedful days, to manufacture deceptive wares or sell adulterated goods. It leaves its accustomed city haunts, goes among the green fields in the pure air of the country, and seeks victims among the farmers. It does more: seeks to develop dishonesty among the moral weaklings of the farming class.

Twenty-five million people, living in comparative isolation, industrious and prosperous, present tempting inducements to men who live on the fruits of the labor of others, which have been improved for years by many sharpers; and the agricultural press has exposed the tricks and frauds attempted, preventing much loss, without eradicating the evil.

These dishonest schemes take protean forms, and appear in manifold guise and disguise. They appeal to the farmer's ambition, economy, and cupidity. They offer, now a machine, labor-saving and effective; again, a variety of fruit tree or plant of marvelous productiveness and phenomenal quality. They excite his fears of law and damages for infringement of some patent, and arouse the lurking devil of greed in some artfully presented and speciously arrayed scheme of dishonest gain. There is an opportunity for fraud in the supply of all goods and chattels required on the farm. Trees, plants, fertilizers, farm implements, household furniture, lightning-rods, books, and crop returns even, are made the opportunity and medium of fraudulent commerce. A prime necessity is the signature of the farmer, and the most ingenious means are taken to obtain it. An order, a receipt, is made to serve the purpose of a promissory note. A favorite ruse is to induce him to act as agent for the sale of some article of farm machinery, leave with him some specimens, taking a receipt for them in such form that, either with or without change, it can be used as a note for the money represented in the goods. Orders for subscription books, in some instances for the revised New Testament, have been converted into notes, which are sold to bank or broker—assumed to be an "innocent" third party—and promptly collected. Another device is the appearance of the sharper as a pretended agent of a bible or tract society, or of some charitable institution, at dinner-time, when he accepts an invitation to dine on the sole condition that he may be permitted to pay for his meal, according to the strict requirement of his society. He takes a receipt in a form which he carries to subserve his artful purpose, which returns to the farmer as a promissory note for any sum which the scoundrel sees fit to fill the blank with.

It would be easy to present many pages of these artifices. If all could be exposed, and every farmer made acquainted with them, the ingenuity of swindlers would devise others of a character equally vile. A few will suffice, and if they shall put their intended victims "on their guard," and prevent their dealing with strangers or giving their signatures in such form as may admit of fraudulent use, the purpose of this article will have been subserved.

A lightning-rod agent agrees to put up lightning-rods about a house for $5, and presents a bill for $105—$100 for the rods and $5 for putting them up. The collection of royalties on some patented article

found in the farmer's possession, the sale of worthless receipts for the manufacture of fertilizers, the sale of rights for a worthless patent process for curing tobacco, the collection of fees by pretended officials, such as boiler-inspectors, "the drive-well fraud," a variety of insurance frauds, and the sale of worthless receipts for the cure of "hog cholera" or other animal diseases, are among the numerous swindling devices mentioned by the correspondents of the Department.

As long as there is rascality on the one side and undue credulity on the other, such swindles will continue to be practiced to a greater or less extent; but they are now practiced successfully in many cases where they might be frustrated by the simple rule of refusing to deal with irresponsible parties without any known business standing or any fixed local habitation. The only additional precautions that suggest themselves as available to the individual are the exercise of reasonable care, the use of proper means to keep informed on agricultural matters, the education of farmers' children in business law, and the use of the facilities for mutual protection offered by such associations as the Patrons of Husbandry or other farmers' organizations. There are, however, some classes of frauds—such as the sale of fertilizers under false names and the manufacture of oleomargarine for sale as butter—which demand the efficient intervention of State or national authority. But even in this matter much must depend upon intelligent concert of action among the farmers themselves, both in suggesting the proper legislation and in bringing to bear on legislatures the influence necessary to insure the proper action.

BOHEMIAN OATS.

As a conspicuous example of these dishonest schemes, the ingenious and complicated "Bohemian oat swindle" was investigated in March, 1886, through the aid of our regular statistical correspondents and State agents. And though the exposure was printed in 15,000 copies of our special reports, and sent to the agricultural press and to thousands of other newspapers, some of which had repeatedly exposed the fraud before, it still lives. Though driven from its principal haunts in the West, it is yet, in March, 1887, to be found in New York, and possibly in many other States. This fraud is of more "hideous mien" than many others, for a long time growing more formidable, emboldened by success, thriving under exposure, persistent in defeat, and fortifying itself anew when driven from its entrenchments. It has entailed losses of hundreds of thousands of dollars; possibly a million dollars would not be an exaggeration.

The history of this swindle covers much time and space. It has lived from year to year under a galling fire of the agricultural and local press. It has thrived not merely through ignorance of its dishonest character but also, it is feared, through an appeal to the cupidity and dishonesty of a small proportion of the agricultural class. While the average character of farmers is believed to be fully as high as that of any large industrial class, it cannot be assumed that there are no "black sheep" in a flock that numbers nine million workers in agriculture.

The magnitude and success of this enterprise is a sufficient reason why this Department, designed for the protection of agriculture and the general welfare of the country, should inquire into the extent and geographical distribution of this prolific crop of frauds.

There are reports of the sale of hulless oats at an exorbitant price

in certain counties in Wisconsin and New York as much as ten years ago, but the swindle does not appear to have taken root in those localities. In its more recent development it is reported on good authority to have been imported from Canada about the year 1880 and planted in Northern Ohio, where it soon attained a particularly vigorous growth. It was early exposed, driven to western, to central, and southern counties, and it soon spread through portions of Indiana and Michigan, and eastwardly into Pennsylvania and New York. During five years it has made its way into every Western State, and made local incursions southward into Kentucky and Tennessee, and is beginning to be heard of in the extreme East.

Correspondents report the attempt, in some form, to sell this grain at exorbitant rates in 25 States, and the presence of the agents of the organized swindle in 18. Ohio is the center of the infection, reports having been received from 45 counties. Indiana makes return of operations in 24 counties; from Michigan come reports from 16 counties, mostly in the southern part of the State, most of them among the richest and most populous, and from 10 counties in different parts of Illinois. In Wisconsin, Minnesota, and Iowa agents have appeared at fewer points, and only an occasional foray has as yet been made into Missouri, Kansas, Nebraska, and Dakota, on the west, and into Kentucky and Tennessee southward. Agents have appeared in several counties in Western New York (10 are reported) and in Pennsylvania, and a few in West Virginia. One is reported in New London, Conn., and one in Waldo, Me. Altogether, there are 130 counties where this fraud is reported, and it is possible, and indeed probable, that a complete report would reveal its existence in 200 counties.

The mode of operating has been exposed so thoroughly and in so many places that it would seem superfluous to describe it, and yet the returns show that it is entirely unknown in many districts, especially in the South, which may soon be invaded by an army of depredators.

A person representing himself as the agent of some distant company appears in the neighborhood and proposes to organize a company or association of farmers for the growth and sale of this grain. He strives at the outset to draw into this enterprise some man whose name will have weight and influence with others to be approached, thus inspiring confidence in his scheme and averting that critical investigation which would inevitably be fatal to its success. The company being formed, it is organized under the local laws.

The members of this association are to monopolize for a year or two at least the production. The grain is furnished, generally in quantities of not less than 10 bushels to any one member, at $10 per bushel, for which the farmer gives his note, payable, with interest, in twelve months. He might hesitate, fearing his inability to reimburse himself for this outlay by the sale of the produce of this seed, but the agent's scheme is reassuring; he offers, on behalf of his company, "a bond," in which it agrees to sell (but not to buy) twice the quantity of oats purchased, at $10 per bushel, less 25 per cent. commission, on or before a certain date, usually a month prior to the date at which the note matures. Thus, if he gives his credit for $100, he expects to receive $200, minus $50 as commission, and thus makes $50 clear before the payment of a dollar. In fact, however, he gets a note which runs another year before collection.

The sale is not limited to 10 bushels, though the agent is careful to convey an idea of limitation in quantity and in number of purchas-

ers, an idea of monopoly. In many cases, however, the lower limit of 10 bushels is broken and 5 are sold, if the buyer proves cautious. There is usually a pretense of limiting sales to one person in each township, while the general practice is to sell to all who will buy and can pay. Sometimes the sale is made for cash, but very rarely; a note payable at a local bank being received as a rule and sold or discounted at once. When due, it is collected by the buyer, an "innocent" third party.

The scheme is intended to run more than a single year, but if exposed too early the agent sometimes fails to appear after harvest to "sell," as "nominated in the bond," the promised quantum of grain. Otherwise he returns, takes orders among other farmers, and receives notes due in twelve months, giving each a bond of the local company formed by the first growers for the sale after harvest of double the quantity sought. He gives these notes in payment for the oats, but takes $2.50 per bushel commission. Selling twenty bushels, he pockets $50, or $100 for forty bushels. He may thus realize several thousand dollars in the neighborhood, leaving the local company to sell after the next harvest the two bushels for each one sold, at the same price. If the excitement can still be kept up, and confidence retained, he can fleece scores of other farmers in farther commissions; but the fraud is usually exposed in the second season, if not in the first, leaving the first growers reimbursed by becoming swindlers themselves, or engaged in numerous lawsuits with fellow-farmers who have been swindled.

The losses that have accrued are already immense; these returns do not give them, except in a few instances; it would require further time, and prove a difficult undertaking, yet it is claimed that in some counties they would reach $10,000. Probably $100,000 would not cover them in Ohio, and possibly the aggregate for all the States would reach several hundred thousand dollars. A loss of $100 by one man is common, and some cases are reported of $1,000.

One of the early promoters of the scheme in northern Ohio, Henry L. Bacon, was last year sentenced to seven years' imprisonment in the Ohio penitentiary, by a court at Akron, for forgeries in connection with this fraud. Others should follow speedily.

The returns relating to quality represent invariably that these Bohemian or hullless oats are of inferior quality, not worth as much as ordinary oats. One of the most competent judges in the country—Mr. Ferdinand Schumacher, the well-known oatmeal manufacturer of Akron, Ohio—in a letter to the Commissioner of Agriculture, dated September 30, 1885, makes the following statements in regard to them:

> I do not want them for oatmeal even at the same price with common oats. I do not know of a mill anywhere using them for oatmeal, and I do not know of a farmer sowing them more than twice. I do not know of any section in this country where the experiment with them has been a success. They have no standing in any of our grain markets.

Mr. W. S. Walker, chief clerk in the office of the secretary of state of Ohio, replying to a question as to the responsibility of one of the Bohemian oat companies of that State, said: "These seed men are a set of swindlers. There is not a dollar of security here for their bonds. Don't deal with them." "Our courts," says H. Talcott, treasurer of the Ohio State Grange of the Patrons of Husbandry, "are full of lawsuits," referring to lawsuits growing out of contracts made in connection with Bohemian oats. In one county (Wyandot) over a dozen cases are said to be on file against Bohemian oats agents.

As the name Bohemian is becoming somewhat notorious, we begin to hear of Australian and Russian oats; and other varieties, or the old variety under other names, may be expected to appear. Cases are also reported from a number of localities in Ohio, Indiana, and other States in which "hulless barley" and pretended new varieties of wheat, bearing such fancy names as "gold dust," "Seneca chief," "red line," &c., are being offered for sale at high prices—the wheat as high as $15 per bushel—and upon the same plan as has been followed with Bohemian oats. It is not necessary to know anything of the quality of the grain offered on that plan to understand that these schemes are fraudulent, because a plan which presupposes that the crop can be sold year after year at the same price as the seed, when the latter is twenty or thirty times the ordinary market price of the grain, manifests a palpable lack of common sense.

AGRICULTURAL EXPORTS VS. IMPORTS.

The exports of the agricultural surplus, commencing when these States were colonies, have attracted the attention of the world, for their volume, if not for their variety. First tobacco, then cotton, wheat, and maize assuming prominence within two or three decades, and meats subsequently, pork products quite early, and beef later, in its "fresh" form, the growth of a single decade. Other exports of agriculture amount to little. The bulk and main value of all come from four crops—cotton, corn, wheat, and tobacco; all except wheat distinctively American in origin, or peculiar adaptation to local climate. The increase since 1860 is seen in the following figures, taken from the official records of customs:

Year.	Cotton.	Breadstuffs.	Tobacco.	Provisions.	Cattle, sheep, and swine.	All products of agriculture.	Per cent.
1860	$191,806,555	$24,422,310	$15,906,547	$16,934,363	$1,463,643	$256,560,972	81.14
1870	227,027,624	72,250,933	21,100,420	30,992,305	724,933	361,188,483	79.34
1880	211,535,905	288,036,835	16,379,107	132,488,201	14,657,931	685,961,091	83.25
1886	205,085,642	125,846,558	27,158,457	90,625,216	11,963,095	484,954,595	72.82

Cotton has remained almost stationary, owing to increase of manufacturing in this country. The increase in breadstuffs has been more than fourfold. The value of tobacco exports has almost doubled. Provisions and farm animals show the largest rate of increase.

Here follow tables showing what products of agriculture are exported and what imported, the difference between exportation and importation slightly exceeding $200,000,000, or less than 7 per cent. of the value of the products of agriculture, and with cotton excluded, barely balancing surplus and deficiency.

Exports of the products of domestic agriculture.

Articles.	1886. Quantities.	1886. Value.
Animals, living:		
Cattle ....number..	119,065	$10,958,954
Hogs ....do....	74,187	674,297
Horses ....do....	1,616	348,323
Mules ....do....	1,191	148,711
Sheep ....do....	177,594	329,844
All other, and fowls	....	58,531
Animal matter:		
Bones, hoofs, and waste	....	127,735
Casings for sausages	....	700,382
Eggs ....dozen..	252,202	46,105
Glue ....pounds..	297,653	42,137
Grease and soap-stock	....	921,337
Hair, and manufactures of	....	407,672
Hides and skins	....	873,925
Honey	....	44,735
Oils:		
Lard ....gallons..	973,229	500,011
Other animal ....do....	360,223	218,643
Provisions:		
Meat products—		
Beef products—		
Beef, canned	....	3,436,453
Beef, fresh ....pounds..	99,423,362	9,291,011
Beef, salted ....do....	58,903,370	3,544,379
Beef, other cured ....do....	824,955	89,593
Tallow ....do....	40,919,951	2,144,499
Mutton ....do....	1,059,435	93,082
Oleomargarine—		
Imitation butter ....do....	928,053	93,363
The oil ....do....	27,729,885	2,954,954
Pork products—		
Bacon ....do....	369,423,351	26,899,111
Hams ....do....	50,365,445	4,741,100
Pork, fresh ....do....	70,749	3,985
Pork, salted or cured ....do....	87,196,966	5,119,426
Lard ....do....	293,728,019	20,361,786
Poultry and game ....do....	....	28,484
Other meat products	....	947,524
Dairy products—		
Butter ....pounds..	18,953,990	2,958,457
Cheese ....do....	91,877,235	7,662,145
Milk	....	255,864
Wax, bees' ....pounds..	136,179	36,626
Wool, raw ....do....	2,138,080	476,274
Total value of animals and animal matter	....	107,539,458
Bread and breadstuffs:		
Barley ....bushels..	252,183	166,330
Bread and biscuit ....pounds..	16,778,850	725,476
Indian corn ....bushels..	63,655,433	31,730,922
Indian-corn meal ....barrels..	293,546	858,370
Oats ....bushels..	5,672,694	1,944,772
Oatmeal ....pounds..	29,495,008	755,973
Rye ....bushels..	196,725	133,105
Rye flour ....barrels..	3,329	12,733
Wheat ....bushels..	57,759,209	50,262,715
Wheat flour ....barrels..	8,179,241	38,442,955
All other breadstuffs	....	813,207
Total value of bread and breadstuffs	....	125,846,558
Cotton and cotton-seed oil:		
Cotton—		
Sea island ....pounds..	4,613,675	1,176,025
Other unmanufactured ....do....	2,053,423,769	203,909,617
Cotton-seed oil ....gallons..	6,240,139	2,115,974
Total value of cotton and cotton-seed oil	....	207,201,616
Miscellaneous:		
Broom corn	....	134,185
Fruits—		
Apples, dried ....pounds..	10,473,183	548,434
Apples, green or ripe ....barrels..	744,539	1,810,606
Preserved—		
Canned	....	580,422
Other	....	28,339
All other	....	340,507

Exports of the products of domestic agriculture—Continued.

Articles.	1886.	
	Quantities.	Value.
Miscellaneous—Continued.		
Hay .... tons..	13,390	$237,902
Hops .... pounds..	13,665,651	1,714,488
Oil cake and oil-cake meal .... do....	585,947,181	7,053,714
Oils—		
Linseed .... gallons....	78,885	41,963
Other vegetable	....	43,519
Rice .... pounds..	256,311	14,241
Seeds—		
Clover .... pounds..	2,652,433	264,882
Cotton .... do....	11,793,411	112,782
Timothy .... do....	4,023,937	175,754
All other	....	1,396,572
Sugar and molasses—		
Molasses and sirup .... gallons..	8,231,282	1,115,437
Sugar, brown .... pounds..	89,523	5,030
Tobacco—		
Leaf .... do....	281,737,120	26,926,544
Stems and trimmings .... do....	11,036,770	231,913
Vegetables—		
Onions .... bushels..	68,811	75,883
Peas and beans .... do....	408,318	570,153
Potatoes .... do....	494,948	346,864
Vegetables, canned	....	190,339
All other, including pickles	....	134,293
Wine—		
In bottles .... dozen..	6,051	24,813
Not in bottles .... gallons..	119,085	93,297
Other agricultural products	....	154,132
Total value of miscellaneous products	....	44,366,963

RECAPITULATION.

Total value of animals and animal matter	$107,539,458
Total value of bread and breadstuffs	125,846,558
Total value of cotton and cotton-seed oil	207,201,616
Total value of miscellaneous products	44,366,963
Total agricultural exports	484,954,595
Total exports	665,964,529
Per cent. of agricultural matter	72.8

Imports of agricultural products, 1886.

Products.	Value.
Sugar and molasses:	
Sugar	$80,773,744
Molasses	5,595,670
Total sugar and molasses	86,369,414
Tea, coffee, and cocoa:	
Tea	16,020,383
Coffee	42,672,937
Cocoa	1,793,398
Total tea, coffee, and cocoa	60,486,718
Animals and their products:	
Cattle	1,281,765
Horses	4,312,636
Sheep	1,006,785
All other and fowls	338,840
Bristles	1,087,137
Butter	23,421
Cheese	855,570
Eggs	2,173,454
Hair	2,469,237
Hides	26,699,313
Meats—	
Preserved, &c	271,512
All other	220,532

Products.	Value.
Animals and their products—Cont'd.	
Milk	$712,410
Oil, animal	3,488
Wools	16,746,081
Total animals and their products.	58,207,181
Miscellaneous:	
Breadstuffs—	
Barley	7,177,887
Indian corn	8,785
Oats	30,792
Oatmeal	49,347
Rye	128,180
Wheat	331,393
Wheat flour	6,274
All other breadstuffs	202,818
Cotton	672,503
Farinaceous substances	693,210
Flax, hemp, jute, &c.—	
Flax	1,576,518
Hemp and substitutes	3,817,376
Jute	2,267,023
Sisal-grass, &c	2,299,459
Fruits and nuts	17,318,259
Hay	1,035,533
Hops	444,989

Imports of agricultural products, 1886—Continued.

Products.	Value.	Products.	Value.
Miscellaneous—Continued.		Miscellaneous—Continued.	
Malt, barley	$237,843	Tobacco—leaf, all other	$7,792,832
Oils, vegetable—		Vegetables—	
Fixed or expressed—		Beans and peas	585,461
Olive	651,590	Potatoes	649,009
Other	1,272,026	Pickles and sauces	323,362
Volatile or essential	947,645	All other	994,347
Rice	2,047,916	Wines—	
Seed	3,266,208	Champagne and other sparkling	3,110,292
Spices—		Still wines—	
Ground	170,423	In casks	2,519,624
Unground—		In bottles	1,310,125
Nutmegs	458,379		
Pepper	1,644,383		
All other	678,936	Total miscellaneous	66,757,918
Tobacco—			
Leaf—			
Suitable for wrappers	37,175		

RECAPITULATION.

Sugar and molasses	$86,369,414
Tea, coffee, and cocoa	60,486,718
Animals and their products	58,207,181
Miscellaneous	66,757,918
Total imports of agricultural products	271,821,231

This exhibit of agricultural exchanges in a nation more prolific in variety, in forms of production, and more abundant in quantity than any other, is a striking illustration of the fact that each country practically provides for itself; that its surplus is mainly the accident of the adjustment of consumption to production, and therefore that foreign trade must ever be a comparatively unimportant consideration to its agriculture.

Circumstances, mainly climatological, have given this country an advantage in growing cotton and tobacco which has amounted almost to a monopoly. The result has been an excessive amount of exportation, favoring our balance of trade, without benefiting correspondingly the districts of largest production. This result was unnecessary, coming from neglect of other branches of agriculture and from dependence on other and distant districts for supplies, even for such bulky products as hay and corn for horses and bread and meat for men. This neglect has reduced the profits of cotton-growing and stimulated production and prices in the regions where surplus grain and meat are produced. The benefit might have been appropriated mainly by the cotton-growing districts, had all necessary supplies been produced at home. Those farmers who are acting on this simple truth in farm economy are advancing rapidly in prosperity.

Leaving out cotton from our list of agricultural exports, $205,085,642 from $484,954,595, the remainder for the past year is $279,868,953. The imports of such products, mostly foods and beverages, amounted to $271,821,231, leaving a beggarly balance exclusive of the cotton exports.

It is a short time since only one-fifth of the cotton and one-third of the tobacco was respectively the amount of domestic consumption. Now one-third of a much larger crop of cotton is required for home manufacture and fully half of the tobacco, and these proportions will be increased in the future, to the great benefit of growers and increased eagerness of foreign buyers.

It will probably prove a surprise to most readers to find that, while the princely sum of $107,539,458 is taken for domestic animals and their products, more than half of it, to wit, $58,207,181, is paid out for animals and their products produced in foreign countries, besides a few millions more for ocean and inland transportation and commissions on the same property. The largest item is hides ($26,-699,313). Imports of manufactured leather are nearly $12,000,000 more. This is the more remarkable, as this country far excels any European country in number of farm animals in proportion to population. It is doubtless a further attestation of the obvious fact that our people are unusually well shod and that the uses of leather are rapidly increasing.

Another annual product which a million farm or ranch proprietors in the United States are engaged in producing was imported last year to the value of $16,746,081, mostly from the South American pampas and Australian sheep-walks. Eggs, a food that could be increased a hundred fold, are among the year's imports to the number of 16,092,583 dozens, costing $2,173,454.

The importation of horses is a large item of the past year's trade, amounting to $4,312,636, and numbering 21,062 free of duty and 37,901 dutiable. The animals imported free are presumably for the improvement of breeds, but really under the letter rather than the spirit of the law as to much the larger proportion, to obtain very cheap stock as a foundation for ranch herds, to be gradually improved by infusion of domestic blood. Thus there were 13,880 horses brought from Mexico last year, "for breeding purposes," costing $7.49 each. The real importation for improvement included 5,288 from Canada, at $224.45 each; 1,123 from France, at $549.93; 698 from Great Britain, at $512.46; and a few from other European countries. The introduction of Mexican bronchos reduces the average of animals imported free to $110.19. The dutiable horses were mainly 21,908 from Mexico, valued at $9.40 each, and 15,854 from Canada, at $111.19. The average of the dutiable horses was $52.55. The exports of horses amounted to only $348,323; in number 1,616, averaging $216 each.

TRANSPORTATION RATES.

In the monthly statistical reports are published current freight rates of railway and steamship transportation companies, to which the reader is referred for details of changes in rates of transportation. These are the regular schedules, but cannot indicate fully the rates actually charged, on account of the special contracts, rebates, and other favors to individual shippers, which are private and confidential.

In this report there is room only for a sample, scarcely a synopsis, of the rates published, sufficient to show the prices of the season for a few principal products by lakes and canal, and also by rail, from Chicago, by one of several lines, and from New York to Liverpool by a single line of several regularly reported in the monthly.

Canal freight on wheat and corn from Buffalo to New York during the season of 1884, 1885, and 1886.

Date.	1884.		1885.		1886.		Date.	1884.		1885.		1886.	
	Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.		Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.
May 7	4	3⅝	....	....	5½	4¾	August 23	4½	4	4	3⅝	6	5¼
May 10	3¾	3¼	....	....	5¾	5	August 30	4⅞	4⅜	4¼	3⅞	5¾	5½
May 17	3½	3¼	4½	4	6¼	5¾	September 6	5	4½	4	3⅝	6	5¾
May 24	3⅜	3¼	3¾	3⅜	5⅞	5¼	September 13	4½	4⅛	3¼	3⅛	6½	6
May 31	3⅝	3¼	3¼	3	5¾	5	September 20	4⅝	4¼	3⅜	3½	6	5½
June 7	3½	3⅛	3¼	3	4¾	4	September 27	4½	4⅛	3½	3⅛	5¾	5¼
June 14	3⅜	3⅛	3⅜	3⅛	3¾	4¼	October 4	4½	4⅛	3⅝	3⅛	6	5½
June 21	3¼	3	3	2⅞	3¼	3	October 11	4½	4	3⅞	3¼	5	4½
June 28	3¼	3	3	2⅞	3½	3¼	October 18	5	4⅛	4	3½	5	4½
July 5	3⅝	3¼	3	2¾	3¾	3¼	October 25	5½	4¾	5	4⅜	5¾	5¼
July 12	3½	3¼	3	2¾	3½	3¼	November 1	5¼	4¾	5¼	5½	5⅞	5⅜
July 19	3⅛	3⅛	3¼	3	4	3⅝	November 8	4¼	3¾	6	5⅜	5¼	5
July 26	3¾	3½	3⅛	2⅞	4¾	4	November 15	4	4¼	4½	4¼	4½	4¼
August 2	3¾	3⅜	3⅛	2⅞	5	4½	November 22	4½	....	4½	4	4¾	4¼
August 9	4	3⅝	3½	3¼	4¾	4¼	November 24	5½	....	4¾	4¼	5¾	5
August 16	4⅛	3⅝	3¾	3¼	5	4½							

Average.	May.	June.	July.	August.	September.	October.	November.
1884—Wheat	3.8	3.4	3.6	4.2	4.7	5.0	4.7
Corn	3.4	3.1	3.2	3.8	4.2	4.4	4.2
1885—Wheat	4.3	3.2	3.0	3.7	3.5	4.1	4.4
Corn	3.8	3.0	2.8	3.4	3.3	3.7	4.0
1886—Wheat	5.8	3.8	4.0	5.3	6.1	5.4	5.2
Corn	5.2	3.4	3.5	4.8	5.6	4.9	4.8

Lake freight on wheat and corn from Chicago to Buffalo during the season of 1884, 1885, *and* 1886.

Date.	1884.		1885.		1886.		Date.	1884.		1885.		1886.	
	Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.		Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.
May 7	2⅛	2	2⅛	2¼	3¼	3	August 22	2	1¾	1⅞	1⅝	3¼	3
May 14	2	1¾	2¼	2	3¾	3½	August 30	2¼	2	2	1¾	3¾	3½
May 22	2¼	2	1½	1¼	2½	2¼	September 7	2¾	2½	1¾	1½	5¼	5
May 31	2¼	1¾	1½	1¼	2¾	2½	September 14	2	1¾	1¾	1½	4¾	4½
June 7	1¾	1¼	1½	1¼	2¼	2¼	September 22	2	1¾	1½	1¼	4	3¾
June 14	2¼	2	1½	1¼	2½	2	September 30	1¾	1½	1½	1¼	4½	4¼
June 22	2½	2¼	1½	1½	3¼	3	October 7	1¾	1½	2	1¾	4¾	4½
June 30	2¼	2	1½	1½	3¼	3	October 14	1⅝	1⅝	2½	2¼	5	4¾
July 7	2	1⅜	2	2	2¼	2	October 22	1¾	1½	2¾	2½	4¾	4½
July 14	2	1¾	1½	1¼	2½	2¼	October 31	2½	2	3¼	2¾	4¼	4
July 22	2	1¾	1¼	1	3¼	3	November 7	2¾	2½	3¾	3½	4½	4¼
July 31	2	1¾	1½	1¼	3	2¾	November 14	2¼	2	3	3	4½	4¼
August 7	1¾	1¾	2	1¾	3	2¾	November 22	2	2	2	2	4¼	4
August 14	1¾	1½	1¾	1½	3	2¾	November 29	2½	2	3¾	3¼	5¼	5

Average.	May.	June.	July.	August.	September.	October.	November.
1884—Wheat	2.2	2.2	2.0	1.9	2.1	2.0	2.8
Corn	2.0	2.0	1.7	1.6	1.9	1.6	2.1
1885—Wheat	2.1	1.4	1.5	1.9	1.7	2.3	3.0
Corn	1.8	1.3	1.3	1.6	1.4	2.2	2.8
1886—Wheat	3.1	2.8	2.8	3.3	4.6	4.7	4.6
Corn	2.8	2.6	2.5	3.0	4.4	4.4	4.4

Rates from Chicago to New York upon certain products, as reported by the several trunk lines upon the 1st day of each month for the years 1884, 1885, and 1886.

Articles.	January—			February—			March—			April—		
	1884.	1885.	1886.	1884.	1885.	1886.	1884.	1885.	1886.	1884.	1885.	1886.
Cattle, C. L....per 100 lbs.	$0 60	$0 40	$0 25	$0 60	$0 40	$0 25	$0 60	$0 40	$0 35	$0 60	$0 40	$0 35
Horses, C. L........do....	60	60	60	60	60	60	60	60	60	60	60	60
Sheep, C. L........do....	60	50	25	60	50	25	60	50	45	60	50	45
Hogs, C. L..........do....	35	30	30	35	30	30	35	30	30	20	25	30
Dressed beef, C. L..do....	64	70	43½	64	70	43½	64	70	65	64	70	65
Grain, C. L..........do....	30	25	25	30	25	25	30	25	25	15	20	25
Flour, C. L..........do....	30	25	25	30	25	25	30	25	25	30	20	25
Potatoes, C. L.......do....	35	30	25	35	30	25	35	30	25	20	30	25
Tobacco, C. L.......do....	37½	27½	33	37½	32	33	37½	32	33	27½	28	38
Lard, C. L..........do....	35	30	30	35	30	30	35	30	30	20	25	30
Pork, C. L..........do....	35	30	30	35	30	30	35	30	30	20	25	30
Wool, C. L..........do....	85	60	60	85	60	60	85	60	60	85	60	60
Lumber, C. L.......do....	35	35	35	35	32	30	35	32	30	30	32	25

Articles.	May—			June—			July—			August—		
	1884.	1885.	1886.	1884.	1885.	1886.	1884.	1885.	1886.	1884.	1885.	1886.
Cattle, C. L....per 100 lbs.	$0 60	$0 40	$0 35	$0 50	$0 30	$0 35	$0 30	$0 25	$0 35	$0 30	$0 25	$0 35
Horses, C. L........do....	60	60	60	60	60	60	60	60	60	60	60	60
Sheep, C. L.........do....	60	50	45	50	40	45	40	40	45	40	40	45
Hogs, C. L..........do....	20	25	30	20	25	30	25	20	30	30	25	30
Dressed beef, C. L...do....	64	70	65	48	70	65	48	43½	65	48	43½	65
Grain, C. L..........do....	15	20	25	15	20	25	20	15	25	25	20	25
Flour, C. L..........do....	15	20	25	15	20	25	20	15	25	25	20	25
Potatoes, C. L.......do....	20	25	25	20	25	25	25	25	25	30	25	25
Tobacco, C. L.......do....	27½	28	38	27½	28	38	27½	28	38	27½	24	38
Lard, C. L..........do....	20	25	30	20	25	30	25	25	30	30	25	30
Pork, C. L..........do....	20	25	30	20	25	30	25	25	30	30	25	30
Wool, C. L..........do....	85	60	60	85	60	60	85	60	60	85	60	60
Lumber, C. L.......do....	30	30	25	30	30	25	30	30	25	30	30	25

Articles.	September—			October—			November—			December—		
	1884.	1885.	1886.	1884.	1885.	1886.	1884.	1885.	1886.	1884.	1885.	1886.
Cattle, C. L.....per 100 lbs.	$0 20	$0 25	$0 35	$0 20	$0 25	$0 35	$0 20	$0 25	$0 35	$0 20	$0 25	$0 35
Horses, C. L........do....	60	60	60	60	60	60	60	60	60	60	60	60
Sheep, C. L.........do....	40	40	45	40	40	45	40	40	45	40	40	45
Hogs, C. L..........do....	30	25	30	30	25	30	30	25	30	30	20	30
Dressed beef, C. L...do....	32	43½	65	32	43½	65	32	43½	65	32	43½	65
Grain, C. L..........do....	25	20	25	25	20	25	25	20	25	25	25	25
Flour, C. L..........do....	25	20	25	25	20	25	25	20	25	25	25	25
Potatoes, C. L.......do....	30	25	25	30	25	25	30	25	25	30	25	25
Tobacco, C. L.......do....	27½	28	38	27½	28	38	27½	28	38	27½	28	38
Lard, C. L..........do....	30	25	30	30	25	30	30	25	30	30	30	20
Pork, C. L..........do....	30	25	30	30	25	30	30	25	30	30	30	30
Wool, C. L..........do....	85	60	60	85	60	60	85	60	60	85	60	45
Lumber, C. L.......do....	30	30	25	30	30	25	35	35	30	35	35	30

Average cost per bushel for transporting wheat from New York to Liverpool, from 1866 to 1886, inclusive.

Years.	Steamer rates.		Sailing-vessel rates.		Years.	Steamer rates.		Sailing-vessel rates.	
	Pence.	*Cents.*	*Pence.*	*Cents.*		*Pence.*	*Cents.*	*Pence.*	*Cents.*
1866	4.74	9.48	....	....	1877	6.93	13.86	6.76	13.52
1867	5.18	10.36	....	....	1878	7.61	15.22	7.09	14.18
1868	7.18	14.36	....	....	1879	6.20	12.40	5.90	11.80
1869	6.40	12.98	....	....	1880	5.88	11.76	5.10	10.20
1870	5.78	11.56	....	....	1881	4.08	8.16	4.75	9.50
1871	8.16	16.32	....	....	1882	3.87	7.76	....	....
1872	7.64	15.28	....	....	1883	4.54	9.08	6.25	12.50
1873	10.56	21.12	9.91	19.82	1884	3.40	6.80	5.00	10.00
1874	9.08	18.16	7.83	15.66	1885	3.60	7.20	....	....
1875	8.07	16.14	7.12	14.24	1886	3.46	6.92	....	....
1876	8.02	16.04	7.64	15.28					

The following are the prices paid for carrying grain from New York to Liverpool during the years 1884, 1885, *and* 1886.

Months.	1884.		1885.		1886.	
	Pence.	*Cents.*	*Pence.*	*Cents.*	*Pence.*	*Cents.*
January	2.35	4.70	5.00	10	3.75	7½
February	2.24	4.48	4.50	9	2.50	5
March	1.56	3.12	3.00	6	2.50	5
April	1.77	3.54	4.00	8	3.50	7
May	1.25	2.50	3.50	7	4.00	8
June	3.08	6.16	3.00	6	4.50	9
July	4.71	9.42	2.75	5½	3.00	6
August	4.63	9.36	3.00	6	2.00	4
September	3.00	6.00	3.50	7	3.00	6
October	4.00	8.00	4.00	8	4.00	8
November	5.79	11.58	4.00	8	4.25	8½
December	6.37	12.74	3.00	6	4.50	9

Inman Line—New York to Liverpool.

Articles.	January—			February—			March—			April—		
	1884.	1885.	1886.	1884.	1885.	1886.	1884.	1885.	1886.	1884.	1885.	1886.
Wheat.........per bushel.	$0 03	$0 10	......	$0 08	$0 09	$0 05	$0 04	$0 06	$0 05	$0 04	$0 08	$0 08
Corn...............do....	03	10	......	08	09	05	04	06	05	04	08	08
Flour ....per bbl.	30	72	......	48	48	36	36	48	36	24	48	48
Flour (in sacks).p. 2,240 lbs.	2 40	4 80	......	3 60	3 60	2 40	2 40	3 60	2 40	1 80	3 60	3 60
Bacon ....do....	3 60 to 4 80	7 20	......	6 00	5 40	3 60	3 60	3 60	3 00	3 00	4 20	4 80
Lard ....do....	3 60 to 4 80	7 20	......	6 00	5 40	3 60	3 60	3 60	3 00	3 00	4 20	4 80
Cheese..............do....	4 80	7 20	......	7 20	6 00	4 80	4 80	4 80	4 20	4 20	5 40	6 00
Beef............per tierce.	84	1 44	......	1 08	96	72	72	60	60	48	84	84
Pork...............per bbl.	60	96	......	84	66	48	48	48	36	30	60	60
Hops ....per lb.	00⅞	00⅞	......	00⅞	00⅞	00¾	00⅞	00¾	00¾	00⅞	00⅝	00⅝
Tobacco..........per hhd.	6 60	7 20	......	7 20	5 40	4 80	6 00	5 40	4 20	6 00	5 40	4 80
Lard (in small packages) ....per 2,240 lbs.	6 00	7 20	......	7 20	6 00	4 80	4 80	4 80	4 20	4 20	5 40	6 00
Tobacco (in cases) ....per 40 cu. ft.	4 80	5 40	......	5 40	4 80	4 20	4 80	4 80	3 60	4 80	4 80	4 20
Measurement per ton ....40 cu. ft.	4 20 to 6 00	4 80 to 6 00	......	4 80 to 6 00	3 60 to 6 00	4 20	3 60 to 6 00	4 80	3 60 to 4 80	3 60 to 6 00	4 80	4 20 to 6 00
Primage..per cent..	5	5	......	5	5	5	5	5	5	5	5	5

Articles.	May—			June—			July—			August—		
	1884.	1885.	1886.	1884.	1885.	1886.	1884.	1885.	1886.	1884.	1885.	1886.
Wheat.........per bushel.	$0 03	$0 07	$0 08	$0 05	$0 06	$0 10	$0 07	$0 05½	$0 06	$0 11	$0 06	$0 04
Corn...............do....	03	07	08	05	06	10	07	05½	06	11	06	04
Flour ....per bbl.	24	48	42	36	36	84	36	36	42	60	48	36
Flour (in sacks).p. 2,240 lbs.	1 80	3 10	3 30	2 40	3 00	3 60	3 00	3 00	3 60	3 90	3 60	2 40
Bacon ....do....	2 40	4 80	4 80	4 20	3 60	6 00	4 20	3 60	4 80	7 20	3 60	3 60
Lard................do....	2 40	4 80	4 80	4 20	3 60	6 00	4 20	3 60	4 80	7 20	3 60	3 60
Cheese..............do....	3 60	6 00	6 00	8 40	6 00	8 40	8 40	7 20	7 20	9 60	7 20	6 00
Beef............per tierce.	48	84	84	72	72	96	84	60	84	1 20	72	60
Pork...............per bbl.	36	60	60	54	48	72	60	48	48	84	54	42
Hops...............per lb.	00⅝	00¾	00⅝	00⅞	00¾	00¾	01	00⅝	00¾	01	00¾	00⅝
Tobacco.. ....per hhd.	5 40	5 40	4 80	6 00	4 80	4 80	6 00	4 80	4 80	6 60	4 80	4 20
Lard (in small packages) ....per 2,240 lbs.	3 60	6 00	6 00	7 20	6 00	7 20	8 40	6 00	7 20	8 40	6 00	4 80
Tobacco (in cases) ....per 40 cu. ft.	3 60	4 80	4 20	4 80	4 80	4 20	5 40	4 20	4 20	6 00	4 20	3 60
Measurement per ton, 40 cubic feet	4 80	4 20 to 6 00	3 60 to 4 80	4 80 to 6 00	3 60 to 6 00	3 60 to 4 80	4 80 to 6 00	3 60 to 4 80	3 60 to 4 80	6 00	4 80	3 60 to 4 80
Primage..per cent..	5	5	5	5	5	5	5	5	5	5	5	5

Inman Line—New York to Liverpool—Continued.

Articles.	September—			October—			November—			December—		
	1884.	1885.	1886.	1884.	1885.	1886.	1884.	1885.	1886.	1884.	1885.	1886.
Wheat........per bushel.	$0 06	$0 07	$0 05	$0 08	$0 08	$0 08	$0 10	$0 08	$0 $08\frac{1}{2}$	$0 14	$0 06	$0 $09\frac{1}{2}$
Corn..............do....	06	07	05	08	08	08	10	08	$08\frac{1}{2}$	14	06	$09\frac{1}{2}$
Flour............per bbl.	42	36	36	48	48	48	60	60	48	72	36	48
Flour (in sacks). p. 2,240 lbs.	3 00	3 00	2 40	3 60	3 60	3 60	3 90	3 60	3 60	6 00	3 00	3 60
Bacon............do....	4 80	4 20	3 60	6 00	4 80	4 80	6 00	7 20	6 00	9 60	6 00	6 60
Lard..............do....	4 80	4 20	3 60	6 00	4 80	4 80	6 00	7 20	6 00	9 60	6 00	6 00
Cheese............do....	6 00	7 20	4 80	7 20	7 20	6 00	7 20	9 00	7 20	10 80	7 20	7 20
Beef..........per tierce.	96	72	60	1 08	84	84	1 08	1 32	96	1 68	1 08	1 08
Pork............per bbl.	72	48	42	84	60	60	84	96	72	1 20	72	84
Hops..............per lb.	01	$00\frac{3}{4}$	$00\frac{1}{2}$	01	$00\frac{7}{8}$	$00\frac{7}{8}$	$00\frac{7}{8}$	$00\frac{7}{8}$	$00\frac{3}{4}$	$00\frac{7}{8}$	$00\frac{3}{4}$	$00\frac{3}{4}$
Tobacco........per hhd.	5 40	4 20	4 20	7 20	4 80	6 60	7 20	6 00	6 00	7 20	4 80	6 00
Lard (in small packages), ...per 2,240 lbs.	6 00	6 00	4 80	7 20	6 00	6 00	7 20	8 40	7 20	10 80	7 20	7 20
Tobacco (in cases), ...per 40 cu. ft	4 80	4 80	3 60	4 80	4 80	4 80	6 00	4 80	4 80	6 00	4 80	4 80
Measurement per ton, 40 cubic feet	4 80	3 60 to 4 80	3 00 to 4 80	4 80 to 6 00	3 60 to 4 80	4 20 to 4 80	4 80 to 6 00	4 80	3 60 to 4 80	6 00	3 60 to 4 80	4 20 to 4 80
Primage. per cent..	5	5	5	5	5	5	5	5	5	5	5	5

FOREIGN TRADE OF SOUTH AMERICA.

The extent of the South American continent, its vast areas of productive lands, and its proximity to the United States are considerations that affect not only our future trade, but our agriculture. Its condition hitherto is like that of North America at the time of our Revolutionary war; its practically illimitable areas unoccupied, except very sparsely, if not by an aboriginal population, by a Spanish-Indian element almost equally intractable and inefficient as subduers of nature to the uses of man. A small sprinkling of European immigration has given whatever of progress has been made. But a new era is dawning. Immigrants are of late pouring into the temperate zone, especially into the Argentine Republic, from Italy, Spain, and other countries of Southern Europe, literally by millions, bringing money, agricultural implements (the more enterprising ordering them from the manufacturers of the United States), knowledge of modern agricultural methods, and a good degree of enterprise and ambition. The rapid extension of railroads opens up new lands, on which agricultural colonies are located, and wheat, flax, and other products are already largely grown, and seeking export.

From this immigration, railroads connecting the fat pampas with salt-water navigation, and the enticing cheapness of these productive lands, a competition with our meat and wheat and wool may become more serious than any heretofore suffered. India is populous and unenterprising, with old and worn soils, sending only 5 to 15 per cent. of her wheat, and liable in any year to need it all to save her people from famine. The Argentine Republic has a virgin soil, few people to feed, and can soon send 50 to 75 per cent. of wheat produced to foreign countries. India plows with a stick and thrashes with the hoof of oxen; the Argentine Republic and Chili are moving for the best steel plows and the finest American reapers and thrashers. Our competition in wheat is to be serious with South America, when apprehensions of Indian competition yield to pity for her famine-stricken people.

The external commerce of South America is increasing rapidly. Chili has nearly doubled her volume of trade in ten years. In round numbers the advance from 1874 to 1883 inclusive has been from $32,000,000 to $73,000,000 in exports, and from $35,000,000 to $50,000,000 in imports. The increase in exports has been all in the last half of this period, making the favorable balance of trade a source of national prosperity. In the Argentine Republic the advance in exports for the same period has been from $41,000,000 to $66,000,000, and of imports from $34,000,000 to $91,000,000. The agricultural implements and other merchandise brought into the country recently by immigrants as a part of their working capital, and paid for from money brought with them from other countries, does not represent indebtedness. This increase is all since 1881, as the imports of 1884 were not exceeded in a single year until 1882, when an increase of 70 per cent. resulted in three years. Uruguay shows an increase also from $15,000,000 to $24,000,000 in exports and from $17,000,000 to $20,000,000 in imports. Other countries have made variable rates of advance, the exact data for which are not at present available.

The United States has as yet only a small share in this commerce. Great Britain has encouraged and ordered the establishment and support of steamship lines and fostered railroad communication, and furnished capital for industrial development of these countries, especially the Argentine Republic and Chili, and therefore controls their trade. The London Statist claims for this development a prominent place in the consideration of British commercial circles, "as the bulk of the public debt of those States is held in this country, and as British capital has built and supplied the material of all the railways finished and in course of construction, as well as for nearly all other industrial undertakings in the Argentine Republic and Uruguay."

Our trade with all South American countries in the year ended June 30, 1885, included a value of $65,289,956 in imports, and less than half as much in exports, or $27,734,857. Of the imports, the larger part, or $45,263,660, were from Brazil, and included 406,714,346 pounds of coffee, worth $30,346,792. Thus we pay more for Brazilian coffee than the value of all exports to South America, and discredit the commercial fallacy that all trade is barter, and that one country will not buy the goods of another unless it can sell its surplus products in liquidation of the bill to that particular country.

The following statement of our trade in 1885–'86 is from the official records of the Bureau of Statistics of the Treasury Department:

Imports of the United States from South America in 1885–'86.

Articles.	Argentine Republic.	Brazil.	Chili.	United States of Colombia.	Uruguay.	Venezuela.	All other countries and ports in South America.	Total.
	Dollars.	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*
Cocoa	....	214,231	....	98,775	....	102,515	538,633	954,154
Coffee	....	26,384,150	....	659,501	....	4,208,480	9,576	31,261,707
Cotton, and manufactures of	....	15	....	374	....	....	773	1,162
Guano	....	....	....	....	....	32,661	....	32,661
Fruits, including nuts	....	141,207	....	307,205	....	509	3,450	452,371
Hides and skins, other than fur skins	2,746,771	2,283,001	21,410	1,280,048	3,094,945	1,292,794	421,573	11,090,542
India-rubber and gutta-percha, crude	....	6,894,689	....	341,981	....	21,011	333,246	7,590,927
Oils, olive and other	....	16	....	....	....	....	....	16
Seeds, linseed, flaxseed, and other	274,794	1,053	....	....	....	124	....	275,971
Sugar and molasses	....	5,506,507	....	1,513	....	....	1,903,924	7,411,944
Tobacco, and manufactures of	....	852	....	83	....	....	....	935
Wool, raw, and manufactures of	1,183,765	151,084	136,441	356	1,336,990	16,560	9,632	2,834,828
Wood, and manufactures of	1,426	63,145	....	85,326	....	13,796	112	163,805
Hair	361,086	107,110	....	392	209,629	47	6	678,270
Paper-stock, crude	787	....	....	1,682	650	27	70	3,216
Feathers and flowers	36,318	768	138	50	10,694	1,991	....	49,959
Cinchona	....	110	....	31,229	....	2,543	9,837	43,719
Furs, and manufactures from	96,124	736	100	155	5,309	....	....	102,424
Hats, bonnets, &c	....	11,670	....	137	....	15,318	27	27,152
Iron, steel, and manufactures of	22,782	20,840	5	1,327	....	....	6,798	51,752
Soda	....	....	952,022	87	....	....	650,886	1,602,995
Ivory	....	501	....	126,563	....	14,000	1,661	142,725
Dye-woods, and extracts of	....	15,179	....	3,871	....	22,924	411	42,385
Fertilizers	103,244	....	....	....	120,172	....	....	223,416
Copper	....	19	33,824	21,628	....	180	117	55,768
All other articles	195,249	110,649	38,905	96,638	147,459	46,141	145,580	780,621
Total	5,022,346	41,907,532	1,182,845	3,008,921	4,925,848	5,791,621	4,036,812	65,875,425

These imports are comparatively uniform from year to year. In the past year (1885–'86) the value is $65,875,425, a very small increase over the previous year. All countries except Brazil and Venezuela show increase, and the decline in these is due to decreased value of coffee rather than diminished quantity. The importation of 1884–'85 amounted to 406,714,346 pounds from Brazil, averaging about 7.5 cents per pound; in the past year 392,058,002 pounds, at about 6.7 cents per pound. Seven-eighths of all the coffee imported comes from South America. The sugar from Brazil was valued at 2.5 cents per pound. The value of the importation of the previous year was 2.1 cents per pound.

The increase of wool imported is large, from $1,687,109 in 1884–'85 to $2,834,828 in 1885–'86. The main increase is from Uruguay, and is caused by a reduction in value of clothing wool from 14.3 cents to 10.5 cents, which had the effect of increasing receipts from 2,123,040 to 12,362,329 pounds. Most of the receipts from the Argentine Republic were classed as carpet wools, and valued at 9.6 cents and 9.4 cents; a slight decrease, accompanied by a slight increase in quantity from 9,851,121 to 10,456,556 pounds.

It will be seen that the imports from Brazil are mainly coffee, rub-

ber, and sugar; of the Argentine Republic, hides and wool; Chili, soda and wool; Colombia, hides, coffee, rubber, and cinchona; Uruguay, hides and wool; Venezuela, coffee and hides. Coffee represents half the value of imports; hides, one-sixth; sugar and india-rubber each over one-tenth; wool and soda, some millions of dollars, and the other articles a comparatively small amount. The large item in the column for "Other countries," $650,886 is for 42,367,498 pounds nitrate of soda, and is from Peru.

Exports to South America in 1884–'85 *and* 1885–'86.

Countries.	1884–'85.			1885–'86.		
	Domestic.	Foreign.	Total.	Domestic.	Foreign.	Total.
Argentine Republic	$4,327,026	$349,475	$4,676,501	$4,331,770	$393,876	$4,725,646
Brazil	7,258,035	59,258	7,317,293	6,480,738	60,478	6,541,216
Chili	2,192,672	18,335	2,211,007	1,973,548	10,058	1,983,606
French Guiana	107,492	3,352	110,844	105,719	3,438	109,157
British Guiana	1,631,608	9,049	1,640,657	1,554,726	29,568	1,584,294
Dutch Guiana	296,667	2,351	299,018	293,071	4,247	297,318
Peru	735,979	6,126	742,105	798,577	15,120	813,697
Colombia	5,397,412	185,957	5,583,369	5,294,798	185,659	5,480,457
Uruguay	1,601,759	80,684	1,682,443	1,110,545	110,531	1,221,076
Venezuela	2,992,968	50,641	3,043,609	2,695,488	37,342	2,732,830
Other countries	425,563	2,448	428,011	638,343	4,351	642,694
Total	26,967,181	767,676	27,734,857	25,277,323	854,668	26,131,991

Among the products of our agriculture exported, as above, during two years past the following are the principal:

Products.	Brazil.		United States of Colombia.		Venezuela.		Total for South America.	
	1884–'85.	1885–'86.	1884–'85.	1885–'86.	1884–'85.	1885–'86.	1884–'85.	1885–'86.
Wheat ......bushels	23,861	4,995	....	506	3,372	1,853	27,233	7,371
Flour........barrels	674,230	542,499	61,360	64,714	143,064	127,085	1,029,232	882,074
Apples.........do	2,102	1,796	1,390	1,477	789	1,526	5,002	5,581
Beef.........pounds	24,100	27,950	733,143	681,898	59,008	29,680	2,421,161	2,811,328
Bacon..........do	309,551	378,718	44,409	48,053	6,550	13,896	541,766	533,792
Hams..........do	1,961	9,591	346,859	345,158	284,259	261,612	929,619	865,666
Butter.........do	89,718	185,228	467,662	460,271	468,235	426,605	1,247,124	1,237,964
Cheese.........do	439	736	342,039	338,165	30,716	28,048	585,933	562,680
Tobacco........do	12,248	53,549	301,810	415,689	113,837	163,511	2,583,333	3,015,594

The exports of agricultural implements to South America were as follows:

Countries.	1884–'85.	1885–'86.
Argentine Republic	$320,912	$591,588
Brazil	14,613	16,848
Chili	71,965	81,006
United States of Colombia	2,188	2,533
Peru	8,540	6,652
Uruguay	157,327	51,652
Venezuela	2,548	1,817
Other countries	786	1,541
Total	578,879	753,637

Textile manufactures, lumber, carriages, and other products of industry comprise the other exports to South America.

ARGENTINE REPUBLIC.

The following table is a statement of the volume of trade, the total value, including bullion and specie, of imports for home consumption and exports of domestic produce for each year:

Years.	Imports.		Exports.	
	Pesos nacionales.	Dollars.	Pesos nacionales.	Dollars.
1874	55,961,000	54,002,365	43,105,000	41,596,325
1875	55,766,000	53,814,190	50,331,000	48,569,415
1876	36,070,000	34,807,550	48,091,000	46,407,815
1877	40,443,000	39,027,495	44,770,000	43,203,050
1878	43,759,000	42,227,435	37,524,000	36,210,660
1879	46,364,000	44,741,260	49,358,000	47,630,470
1880	45,536,000	43,942,240	58,381,000	56,337,665
1881	55,706,000	53,756,290	57,938,000	55,910,170
1882	61,246,000	59,102,390	60,389,000	58,275,385
1883	80,436,000	77,620,740	60,208,000	58,100,720
1884	94,056,000	90,764,040	68,030,000	65,648,950

The following statement of exports of hides and skins from the Argentine Republic is made on the authority of Consul Baker for the latest years reported:

Articles.	1883.		1884.	
	Quantity.	Value.	Quantity.	Value.
Dry ox and cow hides ....number..	1,392,498	$5,255,927	1,706,905	$5,894,306
Salted ox and cow hides ....do....	517,270	2,890,443	642,804	2,923,602
Dry horse hides ....do....	38,211	57,450	72,325	134,762
Salted horse hides ....do....	221,156	540,912	209,126	413,963
Sheep-skins ....kilograms..	26,564,619	5,635,886	24,938,623	5,484,952
Goat-skins ....do....	830,960	940,470	931,070	1,017,046
Carpincho-skins ....number..	22,701	22,704	35,143	17,572
Nutria-skins ....kilograms..	491,217	392,770	407,549	244,405
Other skins	....	65,960	....	118,115

URUGUAY.

The total values, including bullion and specie, of imports for home consumption and exports of domestic produce for each year are as follows:

Years.	Imports.		Exports.	
	Pesos fuertes.	Dollars.	Pesos fuertes.	Dollars.
1874	17,182,000	16,580,630	15,245,000	14,711,425
1875	12,431,000	11,995,915	12,694,000	12,249,710
1876	12,800,000	12,352,000	13,727,000	13,246,555
1877	15,046,000	14,519,390	15,899,000	15,342,535
1878	15,928,000	15,370,520	17,492,000	16,879,780
1879	15,950,000	15,391,750	16,646,000	16,063,390
1880	19,479,000	18,797,235	19,752,000	19,060,680
1881	17,919,000	17,291,835	20,229,000	19,520,985
1882	18,175,000	17,538,875	22,063,000	21,290,795
1883	20,322,000	19,610,730	25,222,000	24,339,230

CHILI.

The total values, including bullion and specie, of imports for home consumption and exports of domestic produce for each year are as follows:

Years.	Imports.		Exports.	
	Pesos fuertes.	Dollars.	Pesos fuertes.	Dollars.
1874	38,418,000	35,037,216	35,541,000	32,413,392
1875	38,137,000	34,780,944	35,928,000	32,766,336
1876	35,291,000	32,185,392	37,848,000	34,517,376
1877	29,213,000	26,642,256	29,715,000	27,100,080
1878	25,217,000	22,997,904	31,696,000	28,906,752
1879	22,795,000	20,789,040	42,658,000	38,904,096
1880	29,716,000	27,100,992	51,648,000	47,102,976
1881	39,565,000	36,083,280	60,526,000	55,199,712
1882	50,992,000	46,504,704	71,210,000	64,943,520
1883	54,447,000	49,655,664	79,733,000	72,716,496

ARGENTINE REPUBLIC.

The distribution of the trade of the Argentine Republic for 1884 was as follows:

Countries.	Imports.		Exports.	
	Pesos nacionales.	Dollars.	Pesos nacionales.	Dollars.
Germany	8,869,000	8,558,585	6,814.000	6,575,510
Holland	1,105,000	1,066,325	2,000	1,930
Belgium	7,250,000	6.996,250	14.880,000	14,359,200
United Kingdom	30,728,000	20,652,520	7,211,000	6,958,615
France	16,785,000	16,197,525	22,518,000	21,729,870
Spain	4,702,000	4,537,430	1,518,000	1,464,870
Italy	3,997,000	3,857,105	1,804,000	1,740,860
United States	7,455,000	7,194,075	4,065,000	3,922,725
Brazil	2,333,000	2,251,345	1,462,000	1,410,830
Uruguay	5,683,000	5,484,095	2,111,000	2,037,115
Chili	12,000	11,580	2,082,000	2,009,130
Paraguay	1,414,000	1,364,510	94,000	90,710
Other countries	3,723,000	3,592 695	3,469,000	3,347,585
Total	94,056,000	90,764,040	68,030,000	65,648,950

This table shows that Great Britain supplies the Argentine Republic with about one-third of its needed merchandise, and, notwithstanding this prominence in its trade and control of its land and water avenues of transportation, takes less than one-fourth as large a value of merchandise in return. France stands next in its proportion of the Argentine supplies, and though sending less than two-thirds as much as Great Britain, receives more than three times as much as that country, paying $5,000,000 or $6,000,000 difference. Germany occupies the third place while the United States comes fourth, sending goods valued at more than $7,000,000, and receiving in return little more than half as much, simply because there happened to be a demand for agricultural implements and other American products.

URUGUAY.

[From No. 12 British Statistical Abstract Foreign Countries.]

1883.

Countries.	Imports.		Exports.	
	Pesos fuertes.	Dollars.	Pesos fuertes.	Dollars.
Germany	2,030,000	1,958,950	689,000	664,885
Holland	115,000	110,975	....	....
Belgium	596,000	575,140	4,871,000	4,700,515
United Kingdom	5,515,500	5,321,975	4,831,000	4,661,915
France	3,491,000	3,368,815	4,231,000	4,082,915
Spain	2,093,000	2,019,745	230,000	221,950
Portugal	45,000	43,425	66,000	63,690
Italy	1,314,000	1,268,010	318,000	306,870
United States	1,174,000	1,132,910	2,187,000	2,110,455
Cuba	224,000	216,160	1,076,000	1,038,340
Chili	99,000	95,535	47,000	45,355
Brazil	2,213,000	2,135,545	3,352,000	3,234,680
Argentine Republic	744,000	717,960	2,056,000	1,984,040
Paraguay	83,000	80,095	....	....
Other countries	586,000	565,490	1,268,000	1,223,620
Total of principal and other countries	20,322,000	19,610,730	25,222,000	24,339,230

The imports of Uruguay are obtained from Great Britain, France, Brazil, Spain, Germany, Italy, the United States, the Argentine Republic, in the order named, and in smaller proportion from a few other countries. The exports are greater than the imports, and the principal buyer of these products is Belgium, a country that contributes one-tenth as much as Great Britain to the volume of Uruguayan importation. France, the United States, Brazil, and the Argentine Republic also receive more than they send to Uruguay, while Great Britain, Germany, Italy, and Spain send more than they receive, the latter two in much larger percentages of difference. The immigration of representatives of the Latin race accounts for this disproportion.

CHILI.

1883.

Countries.	Imports.		Exports.	
	Pesos fuertes.	Dollars.	Pesos fuertes.	Dollars.
Germany	10,016,000	9,134,592	4,811,000	4,387,632
Belgium	213,000	194,256	190,000	173,280
United Kingdom	21,638,000	19,733,856	58,962,000	53,773,344
France	8,935,000	8,148,720	6,209,000	5,662,608
Spain	420,000	383,040	....	....
Italy	531,000	484,272	....	....
United States	3,601,000	3,284,112	1,667,000	1,520,304
Brazil	693,000	632,016	129,000	117,648
Argentine Republic	3,617,000	3,298,704	323,000	294,576
Uruguay	434,000	395,808	317,000	289,104
Ecuador	272,000	248,064	393,000	358,416
Peru	3,533,000	3,222,096	4,111,000	3,749,232
Colombia	....	....	772,000	704,064
Cape of Good Hope	....	....	18,000	16,416
Other countries	544,000	496,128	1,831,000	1,669,872
Total of principal and other countries	54,447,000	49,655,664	79,733,000	72,716,496

Chili also exports more than enough to pay for imports. Great Britain is again most prominent in the trade, but while almost monopolizing the exports, taking nearly three-fourths of the whole, she supplies less than four-tenths of the requirement of imports, the disproportion being $54,000,000 to $20,000,000 and pays $34,000,000 cash beyond receipts for the goods supplied to the Chilians.

Germany and France come next in prominence of supply, and both buy less than they sell, taking orders for goods brought through British mails on British steamships, which bear away the productions of Chili. As in other countries, there is no necessary relation between the exports and imports exchanged between countries and generally marked inequality in the record, each buying what is needed most and selling to countries that need most the goods that are for sale, paying in cash and never in barter.

The rate of increase of wheat exportation from Chili and the Argentine Republic is more significant than the quantity of it. Until 1883 only Chili was separately mentioned in the British official publication of wheat importation. It is not large now, but increasing, with abundant opportunity for a tenfold increase in the near future if agricultural enterprise should take this direction strongly. Examination of these records shows that South American wheat received into Great Britain in the past two years was as follows in quantity and value:

Countries.	1884.		1885.	
	Bushels.	Value.	Bushels.	Value.
Chili	1,971,133	$2,128,305	3,029,324	$3,109,543
Argentine Republic	392,829	424,962	623,831	585,026
United States of Colombia	79,798	86,356	144,465	138,306
Brazil	66,050	64,793	....	....
Uruguay	....	....	24,024	23,359

The cotton imports into Great Britain from South American countries, as recorded in official reports, are as follows:

Countries.	1881.		1882.		1883.		1884.		1885.	
	Quantities.	Value.	Quantities.	Value.	Quantities.	Value.	Quantities.	Value.	Quantities.	Value.
	Cwts.	£.	*Cwts.*	£.	*Cwts.*	£.	*Cwts.*	£.	*Cwts.*	£.
U. S. of Colombia	32,609	115,342	21,981	91,825	13,827	59,766	12,364	50,981	10,749	36,427
Peru	35,749	129,664	37,958	137,531	37,743	132,033	27,230	92,607	36,258	121,495
Chili	12,169	36,343	20,577	70,924	13,544	46,544	12,263	44,138	13,931	47,863
Brazil	358,262	1,065,504	482,611	1,510,432	438,919	1,291,798	353,782	1,033,429	322,058	916,451
Venezuela	118	331	240	672	....	....	....	....	....	....
Ecuador	12	34	3	13	....	....	75	259	....	....

RAILROADS.

The railroad enterprise of South America is in its infancy. Peru opened its first line in 1851, Chili in 1852, Brazil in 1854, and the Argentine Republic in 1864. Much more than half of the present mileage has been built within ten years. In 1877 the aggregate was 4,558 miles; in seven years, up to the end of 1884, it was 9,835 miles, an increase of 4,207 miles, or 92 per cent. The increase of the past year is not at hand. The details are as follows:

Countries.	1877.		1884.		Increase of miles.
	Kilometers.	Miles.	Kilometers.	Miles.	
Colombia	103	64	243	151	87
Venezuela	147	91	164	102	11
British Guiana	....	....	34	21	21
Brazil	2,600	1,616	6,115	3,800	2,184
Argentine Republic	2,240	1,392	4,576	2,843	1,451
Uruguay	376	234	431	268	34
Paraguay	72	45	72	45	....
Chili	1,625	1,010	2,275	1,414	404
Peru*	....	....	1,852	1,151	....
Bolivia†	130	81	....	....	....
Ecuador	41	25	64	40	15
	‡7,334	‡4,558	15,826	9,835	‡4,207

*The record of Peru is incomplete as to 1877.
†The district in Bolivia in which these roads are situated has become a part of Chili.
‡Exclusive of Peru.

While the increase since 1877 is little more than that of the United States for the past year, the advance is very rapid, and the future acceleration may be more striking if immigration from Europe continues. Already the mileage is near to that of India, and may soon be quite in advance of that populous Empire. The railway mileage of the world was in 1884 292,166 miles, of which the United States had 125,378, and at the end of 1885 our mileage was 128,966.

The increase of mileage in 1885 and 1886 has been large, though not given in the table above. The London *Statist* states that there are 5,600 kilometers completed in the Argentines, and additional lines of equal extent in course of construction. The great railway centers are Buenos Ayres and Rosario. The Great Southern line leads to Bahia Blanca, and the borders of Patagonia; another runs to Rosario. From Rosario the Great Northern and Tucuman leads northward, and is to be extended to Bolivia. From Mercedes the Trans-Andine line is to be extended to Valparaiso on the Pacific coast, connecting transportation of the Pacific and Atlantic. Other lines are to connect Entre Rios, Corrientes, Santa Fé, Cordova, and San Luis.

In Uruguay a grand trunk-line system, with lateral branches, will extend from Montevideo to the Brazilian frontier, thence to Itagui in Rio Grande do Sul, seeking the vast possibilities of traffic beyond. There is in operation already a stretch of 75 miles to Durasno. The Northwestern of Uruguay is in course of construction. This occupies a region above Salto, the head of navigation for sea-going vessels, opening a productive region above the rapids.

FARM ANIMALS OF THE WORLD.

The following table embraces such statistics of farm animals as it was practicable to obtain for each of the grand divisions of the world, but many countries are necessarily omitted for want of any trustworthy information from either official or private sources. It will be understood that the totals presented below for the several grand divisions include only the countries, and in a few instances parts of countries, named in the table. The figures for the United States, Canada, the principal European nations, except Spain, the British colonies, and a number of other countries, are official. In other cases the best information obtainable from private sources has been used. The returns for a few countries were not made in such a manner as to con-

form to the classification adopted in the table, goats, for example, being in some cases included with sheep, mules with horses, &c. Where this is the case the fact is pointed out in a foot-note.

Countries.	Years.	Cattle.	Horses.	Mules and asses.	Sheep and lambs.	Swine.	Goats.
NORTH AMERICA.							
United States	1887	48,033,833	12,496,744	2,117,141	44,759,314	44,612,836	...
Canada:							
Ontario and Quebec	1881	2,732,500	864,150	...	2,249,011	1,030,121	...
Nova Scotia	1881	325,603	57,167	...	377,801	47,256	...
New Brunswick	1881	212,560	52,975	...	221,163	53,087	...
Manitoba	1881	60,281	16,739	...	6,073	17,358	...
Prince Edw. Island	1881	90,722	31,335	...	166,496	40,181	...
British Columbia	1881	80,451	26,122	...	27,788	16,841	...
The Territories	1881	12,872	10,870	...	346	2,775	...
Total	1881	3,514,989	1,059,358	...	3,048,678	1,207,619	...
Newfoundland	*a*1875	13,938	4,057	...	28,766	*a*6,417	...
Jamaica	1885	130,532	62,845	...	13,390	...	...
Nicaragua	?1884	400,000	...	...	...	...	...
Guadaloupe	?1880	9,615	5,988	7,619	13,690	14,116	14,709
Guatemala *b*	1884	441,207	107,187	*c*41,366	417,577	...	...
Grand total	...	52,544,214	13,736,179	2,166,126	48,281,415	45,840,988	14,709
SOUTH AMERICA.							
Argentine Republic	*d*1885	18,000,000	5,000,000	*d*600,000	75,000,000	250,000	*d*3,000,000
Falkland Islands	1885	7,934	3,009	...	516,975	...	...
Paraguay	1882	500,000	...	...	...	...	...
Uruguay	1884	5,952,349	480,686	*c*5,742	15,921,069	100,000	5,656
Venezuela	1883	2,926,733	291,603	906,467	*e*3,490,563	976,500	(*e*)
Total	...	27,387,016	5,775,298	1,512,209	94,928,607	1,326,500	3,005,656
EUROPE.							
Austria-Hungary:							
Austria	1880	8,584,077	1,463,282	49,618	3,841,340	2,721,541	1,006,675
Hungary, including Croatia and Slavonia	1880	5,311,378	2,078,528	33,746	9,838,133	4,160,127	333,233
Belgium	1880	1,382,815	271,974	10,120	365,400	646,375	248,755
Denmark	1881	1,470,078	347,561	*f*282	1,548,613	527,417	9,331
France	1885	13,104,970	*g*2,911,392	625,247	22,616,547	5,881,088	1,483,342
Germany	1883	15,786,764	3,522,545	9,795	19,189,715	9,206,195	2,639,994
Great Britain and Ireland:							
Great Britain	1886	6,646,683	1,425,359	...	25,520,718	2,221,475	...
Ireland	1886	4,184,027	492,831	...	3,367,722	1,263,133	...
Isle of Man, &c	1886	42,101	9,337	...	66,800	12,557	...
Total	1886	10,872,811	1,927,527	...	28,955,240	3,497,165	...
Greece *h*	*i*1877	279,445	97,176	142,835	2,921,917	*i*179,602	1,836,663
Italy	*k*1881	4,783,232	*k*660,123	*l*968,114	8,596,108	1,163,916	2,016,307
Netherlands	1884	1,474,412	269,074	...	752,949	426,914	156,255
Portugal	1870	624,658	...	...	2,977,454	971,085	936,863
Roumania	*m*1884	2,376,066	600,000	...	4,654,776	2,310,000	...
Russia in Europe *n*	1882	23,845,104	20,015,659	...	47,508,966	9,207,666	1,374,805

a The figures as to hogs in Newfoundland are for 1869.
b The total value of live-stock in Guatemala at the same time was estimated at $15,102,233.
c Mules only.
d The figures as to mules and asses in the Argentine Republic, and those as to goats in the same country, are for 1883.
e Goats are included with sheep.
f Asses only.
g Exclusive of about 70,000 horses in the city of Paris.
h Thessaly, which has become a part of the Greek Kingdom since 1877, is not included in these figures. The number of live stock in this province has been estimated to include 200,000 oxen, 1,500,000 sheep, and 1,000,000 goats.
i The figures as to swine in Greece are for 1875.
k The figures as to horses in Italy are for 1882.
l The figures as to mules embraced herein are for 1876, the number of these animals in that year being 293,868. This leaves 674,246 as the number of asses in 1881.
m The figures as to horses and those as to swine in Roumania are for 1880.
n Exclusive of Poland.

Countries.	Years.	Cattle.	Horses.	Mules and asses.	Sheep and lambs.	Swine.	Goats.
Servia	1882	826,550	122,500	....	3,620,750	1,067,940	725,700
Spain	1878	2,353,247	....	1,832,635	16,939,288	2,348,602	3,813,000
Sweden and Norway:							
Sweden	1884	2,327,003	476,008	....	1,410,177	476,889	101,496
Norway	1875	1,016,617	151,903	....	1,686,306	101,020	322,861
Switzerland	1886	1,210,849	98,212	*c*2,732	337,905	394,330	414,584
Turkey in Europe: *a*							
Eastern Roumelia	1883	370,862	43,601	33,415	1,858,839	107,442	425,569
Total Europe	....	98,000,938	35,057,065	3,709,139	179,620,423	45,395,314	17,845,433
ASIA.							
Russia: *b*							
Caucasia	(*c*)	1,816,200	309,000	....	4,544,300	....	1,227,000
Transcaucasia *d*	(*c*)	1,900,000	770,000	....	5,067,500	....	....
India: *e*							
Madras	1877-78	*f*7,832,000	39,500	*g*128,000	4,600,000	250,000	2,700,000
Bombay and Sind	1877-78	*f*7,310,000	150,000	*g*90,000	*h*3,300,000	....	Included with sheep.
Punjab	1877-78	*f*6,570,000	137,000	*g*290,000	*h*3,850,000	....	
Central Provinces	1877-78	*f*5,200,000	94,000	*g*22,000	*h*641,000	132,000	
British Burmah	1877-78	*f*1,376,000	5,800	....	*h*20,000	102,000	
Mysore	1877-78	*f*2,300,000	18,900	*g*37,000	*h*1,590,000	32,000	
Berar	1877-78	*f*1,300,000	32,500	*g*17,000	*h*330,000	2,700	
Ceylon	1884	963,896	3,683	....	53,757	....	....
Japan	1882	1,159,750	1,640,523	....	....	....	....
Total	....	37,827,846	3,200,906	584,000	24,052,557	518,700	3,927,000
AFRICA.							
Algeria	1880	1,163,513	350,000	....	6,922,218	300,000	3,293,033
Cape of Good Hope *i*	1875	1,329,445	241,342	....	11,279,743	132,373	....
Natal	1885	600,984	48,729	....	535,482	23,419	....
Mauritius *k*	1884	15,000	*l*12,000	(*l*)	*h*30,000	30,000	(*h*)
Orange Free State	1881	*m*464,575	131,594	....	*n*5,056,301	....	673,924
Total	....	3,573,517	783,665	....	23,893,744	485,792	3,966,957
AUSTRALASIA.							
Australia:							
New South Wales	1885	1,270,078	329,983	....	34,551,622	208,697	....
Victoria	1885	1,265,383	301,258	....	10,664,598	237,048	....
South Australia	1884	389,726	168,420	....	6,696,406	163,807	....
Western Australia	1885	70,408	34,392	....	1,702,719	24,280	....
Queensland	1885	4,162,652	260,207	....	8,994,322	55,843	....
New Zealand	*o*1881	698,637	161,736	....	14,624,547	200,083	....
Tasmania	1885	138,642	28,610	....	1,648,627	67,395	....
Fiji Islands	1884	4,418	*p*610	(*p*)	5,869	....	*q*11,429
Total	....	7,999,944	1,285,216	....	78,888,710	957,153	11,429
OCEANIA.							
Tahiti and Moorea	1883	3,000	1,000	*q*15	3,000	20,000	1,300
Grand total *r*	....	227,336,475	59,839,329	7,971,489	449,668,456	94,544,447	28,772,484

a There are no returns available for Turkey proper, and none for any of her tributary states except Eastern Roumelia.

b There are no returns for Asiatic Russia, except from Caucasia and a part of Transcaucasia.

c The statistics from the different parts of these Governments are not of uniform date, but were gathered within the ten years 1874–1883.

d These figures embrace statistics from the provinces of Bakou, Tiflis, Elizabethpol, Erivan, and Koutais.

e This statement is exclusive of the Northwest Provinces and Oudh and Bengal, with several minor provinces and all the native states except Mysore.

f Bullocks, cows, and baffaloes.

g Asses only.

h Goats are included with sheep.

i Including 217,732 cattle, 35,357 horses, 303,080 sheep, and 15,635 swine in Basutoland.

k Approximate statement.

l Mules and asses are included with horses.

m Breeding-cattle.

n Merinoes.

o The figures as to sheep and lambs are for 1885.

p Mules are included with horses.

q Angora goats.

r See notes above for cases in which the figures given do not exactly conform to the classification indicated in the caption at the head of the column, as where mules only, or asses only, are included under the head of "Mules and asses," or where goats are included with sheep, &c.

WHEAT CROP OF THE WORLD IN 1886.

In the following table the figures for Austria-Hungary, France, Great Britain and Ireland, Italy, Russia (except Poland), Sweden, and India, as well as those for the United States, are official; but only those last named and those for Great Britain and Ireland are the final estimates, unless those for India may be so considered. In the figures for Canada are included the official returns for Ontario and an estimate for Manitoba, based on the official estimate of the area and rate of yield. These two provinces produce nearly nine-tenths of the wheat crop of the Dominion. The figures for Australasia are official, with the exception of those for South Australia, which are from the Adelaide *Observer*. The countries thus far named furnish about four-fifths of the total product embraced in the table.

For the countries credited with the remaining one-fifth the figures are unofficial, all except those for Germany being taken from a table published in the *Echo Agricole* of September 7, 1886.

The countries not included in the table are for the most part countries in which wheat holds a very subordinate position among the staple food products, and which have no appreciable influence upon the general wheat trade of the world:

Countries.	Bushels.	Countries.	Bushels.
America:		Europe—Continued.	
United States	457,218,000	Roumania	22,629,063
Canada	37,219,234	Russia (including Poland)	213,907,084
Argentine Republic and Chili	28,800,625	Servia	4,525,813
Europe:		Spain	131,660,000
Austria-Hungary*	143,001,488	Sweden and Norway	†4,081,115
Belgium	18,514,688	Switzerland	1,645,750
Denmark	4,731,531	Turkey	41,143,750
France	299,107,620	Australasia ‡	22,258,146
Germany	82,000,000	India	258,317,632
Great Britain and Ireland	65,285,353	Egypt	16,457,500
Greece	4,937,250	Algeria	32,915,000
Italy	129,412,133		
Netherlands	4,937,250	Total	2,032,934,775
Portugal	8,228,750		

*The figures for Austria included in this statement are 12,987,000 hectoliters (=36,850,613 bushels), as given in a preliminary official estimate. Those for Hungary are 37,410,000 hectoliters (106,150,875 bushels), as given in the second estimate made by the Hungarian ministry of agriculture.

†The preliminary official figures for Sweden are 1,339,600 hectoliters, or 3,801,115 bushels, to which 280,000 bushels are added for Norway.

‡The wheat crop of Queensland is gathered in the latter part of the year, and the crop for this colony (51,598 bushels), included in the total for Australasia, is the one gathered in the latter part of 1885, which may, however, be regarded as belonging to the same season as the crops which, in the more southern colonies, were mainly harvested in the early part of 1886.

FOREIGN FARM STATISTICS.

GREAT BRITAIN AND IRELAND.

The following table compiled from the "Agricultural Produce Statistics" of Great Britain and the "Agricultural Statistics" of Ireland, both official publications, shows the area and produce of the principal crops of these countries for the years 1884, 1885, and 1886, these three years comprising the entire period for which statistics of produce in Great Britain have been published. The cereal returns for Great Britain are reduced from Imperial to Winchester bushels at the rate

of 1.03152 of the latter to 1 of the former. Those for Ireland are reduced from hundred weights, of 112 pounds, to bushels, at the rate of 60 pounds per bushel for wheat, 48 pounds per bushel for barley, and 32 pounds per bushel for oats. Beans and peas are stated in bushels of 60 pounds. Potatoes, which in the official returns are stated in tons of 2,240 pounds, are reduced to bushels, at the rate of 60 pounds per bushel:

Crops.	1884.		1885.		1886.	
	Area.	Product.	Area.	Product.	Area.	Product.
	Acres.	*Bushels.*	*Acres.*	*Bushels.*	*Acres.*	*Bushels.*
Wheat	2,744,928	84,595,368	2,549,335	82,081,332	2,355,451	65,285,353
Barley	2,336,227	82,497,027	2,436,823	88,489,231	2,423,060	80,841,031
Oats	4,263,807	176,228,395	4,269,359	175,248,232	4,403,579	184,596,748
Beans	454,580	12,101,345	441,054	9,402,792	387,205	10,815,330
Peas	230,618	5,858,621	231,100	4,475,451	215,072	6,057,879
Potatoes	1,364,000	253,252,720	1,346,023	237,971,701	1,353,808	217,858,181
		Tons.		*Tons.*		*Tons.*
Turnips	2,331,641	30,581,246	2,311,942	24,062,608	2,302,159	33,957,415
Mangold	361,905	5,997,139	391,702	5,969,523	386,708	7,785,811
Hay	....	....	8,217,147	12,887,074	8,760,325	13,503,416
				Cwts.		*Cwts.*
Hops	....	....	71,327	509,170	70,127	776,144

The above statement does not include the crops of the Isle of Man and the Channel Islands, which, however, are very insignificant in amount.

The following figures, giving the number of cattle and sheep for 1885 and 1886, and dividing them into certain classes specified, are from the Agricultural Returns of Great Britain for 1886, from which are also obtained the totals for the several kinds of live stock in the United Kingdom given in the table of farm animals of the world:

	Number of head.	
	1885.	1886.
Cattle:		
Cows and heifers, in milk or in calf	3,965,512	3,974,476
Other cattle, two years old and over	2,419,624	2,533,062
Other cattle, under two years old	4,483,624	4,365,273
Total	10,868,760	10,872,811
Sheep:		
One year old and over	18,717,058	18,291,345
Under one year old	11,369,142	10,663,895
Total	30,086,200	28,955,240

FRANCE.

The following statistics of agricultural production in France are from the *Bulletin du Ministère de l'Agriculture* for December, 1886:

TABLE I.—*Area, rate of yield, and product of cereals and potatoes, year* 1885.

	Area.		Rate of yield.		Product.	
	Hectares.	Acres.	Hectoliters per hectare.	Bushels per acre.	Hectoliters.	Bushels.
Wheat	6,956,765	17,190,166	15.79	18.13	109,861,862	311,733,033
Maslin	330,953	817,785	15.68	18.01	5,190,771	14,728,813
Rye	1,672,951	4,133,862	14.39	16.52	24,074,328	68,310,906
Barley	955,616	2,361,327	18.22	20.92	17,415,439	49,416,308
Oats	3,689,628	9,117,071	23.21	26.65	85,530,225	242,692,013
Buckwheat	628,136	1,552,124	13.73	15.77	8,626,318	24,477,177
Maize	560,903	1,386,004	16.09	18.48	9,028,063	25,617,129
			Quintals.		*Quintals.*	
Potatoes	1,437,263	3,551,477	78.24	116.35	112,458,541	413,210,166

TABLE II.—*Annual average for the ten years* 1876–1885.

	Area.		Rate of yield.		Product.	
	Hectares.	Acres.	Hectoliters per hectare.	Bushels per acre.	Hectoliters.	Bushels.
Wheat	6,918,059	17,094,524	14.70	16.88	101,649,375	288,430,102
Maslin	404,705	1,000,026	15.14	17.39	6,112,038	17,342,908
Rye	1,787,428	4,416,735	13.89	15.95	24,827,298	70,447,458
Barley	1,033,215	2,553,074	17.71	20.34	18,297,745	51,919,851
Oats	3,521,278	8,701,078	23.04	26.46	81,189,343	230,374,761
Buckwheat	642,765	1,588,272	15.34	17.62	9,951,169	28,236,442
Maize	622,025	1,537,024	14.86	17.06	9,231,685	26,194,906
			Quintals.		*Quintals.*	
Potatoes	1,328,121	3,281,787	92.90	138.14	123,501,484	453,785,619

Weight of cereals per hectoliter and per bushel.

	First quality.		Second quality.		Third quality.	
	Kilograms per hectoliter.	Pounds per bushel.	Kilograms per hectoliter.	Pounds per bushel.	Kilograms per hectoliter.	Pounds per bushel.
Wheat	79.49	61.76	77.45	60.17	75.19	58.42
Rye	73.41	57.04	71.61	55.64	69.82	54.25
Barley	64.38	50.02	62.15	48.29	59.44	46.18
Oats	49.04	38.10	46.87	36.42	43.91	34.12

Average prices of cereals, potatoes, flour, bread, meat, &c., for 1885 *and for the twenty years* 1866–1885.

	1885.		Average for 1866–1885.	
	Francs.	Dollars.	Francs.	Dollars.
	Per hectoliter.	Per bushel.	Per hectoliter.	Per bushel.
Wheat	16.80	1 14	21.93	1 49
Maslin	13.92	95	17.56	1 19
Rye	12.04	82	14.74	1 00
Barley	11.14	76	12.85	87
Buckwheat	11.16	76	12.22	83
Maize	13.50	92	15.04	1 02
Oats	9.07	62	9.90	67
Potatoes	4.99	34	5.98	41
	Per quintal.	Per barrel.	Per quintal.	Per barrel.
Flour	31.86	5 46	41.01	7 04
Bread:	Per kilogram.	Per pound.	Per kilogram.	Per pound.
First quality	.32	02.8	.39	03.4
Second quality	.27	02.4	.33	02.9
Third quality	.24	02.1	.29	02.5
Butcher's meat:				
Beef (of oxen)	1.63	14.3	1.52	13.3
Beef (of cows)	1.50	13.1	1.41	12.3
Veal	1.72	15.1	1.64	14.4
Mutton	1.84	16.1	1.67	14.6
Pork	1.54	13.5	1.58	13.8
Forage:	Per quintal.	Per ton.	Per quintal.	Per ton.
Hay	7.41	14 53	8.32	16 32
Straw	4.92	9 65	5.32	10 43
Fuel:				
Coal	4.29	8 41	4.21	8 26
Charcoal	10.54	20 67	10.60	20 79
	Per stère.	Per cord.	Per stère.	Per cord.
Oak wood	11.93	8 33	10.77	7 52

Average price of wheat for 1866–1885.

Years.	Per hectoliter.	Per bushel.	Years.	Per hectoliter.	Per bushel.
	Francs.	*Dollars.*		*Francs.*	*Dollars.*
1866	19.59	1 33	1876	20.64	1 40
1867	26.02	1 77	1877	23.42	1 59
1868	26.08	1 77	1878	23.08	1 57
1869	20.21	1 37	1879	21.92	1 49
1870	20.48	1 39	1880	22.90	1 56
1871	26.65	1 81	1881	22.28	1 52
1872	22.90	1 56	1882	21.51	1 46
1873	25.70	1 75	1883	19.16	1 30
1874	24.31	1 65	1884	17.76	1 21
1875	19.38	1 32	1885	16.80	1 14

GERMANY.

The following official statement of the principal crops of the German Empire for the year 1885 is from the *Monatschefte zur Statistik des Deutschen Reichs* for July, 1886:

Crops.	Area.		Metric tons.	Total product, bushels (*a*) and tons,	Average per acre.
	Hectares.	*Acres.*			
Wheat:					
Grain....................bushels..	1,913,821	4,729,052	2,599,271	95,505,881	20.2
Straw....................tons..	....	....	4,231,407.2	4,164,536	.88
Rye:					
Grain....................bushels..	5,826,618	14,397,573	5,820,094.7	229,124,657	15.9
Straw....................tons..	....	....	11,573,223.8	11,390,326	.79
Barley:					
Grain....................bushels..	1,739,524.1	4,298,364	2,260,645.2	103,829,550	24.2
Straw....................tons..	....	....	2,624,263.1	2,582,790	.60
Oats:					
Grain....................bushels..	3,776,837.9	9,332,566	4,342,357.1	299,161,264	32.1
Straw....................tons..	....	....	5,795,893.4	5,704,298	.61
Spelt, &c.:					
Grain....................bushels..	374,553	925,520	466,446.9	17,138,814	18.5
Straw....................tons..	....	....	827,917.4	814,833	.88
Einkorn (*b*):					
Grain....................bushels..	5,539.8	13,689	4,844.3	177,996	13
Straw....................tons..	....	....	10,303.1	10,167	.74
Buckwheat:					
Grain....................bushels..	216,482.2	534,928	118,150.4	5,209,487	9.7
Straw....................tons..	....	....	174,491.2	171,734	.32
Peas:					
Fruit....................bushels..	408,522.5	1,009,459	306,774.4	11,271,914	11.2
Fodder....................tons..	....	....	499,111.9	491,224	.49
Field beans:					
Fruit....................bushels..	144,737.7	357,647	201,255.1	7,398,458	20.7
Stalks....................tons..	....	....	264,937.1	260,799	.73
Vetches:					
Seeds....................tons..	162,828.1	402,348	123,425.5	121,475	.30
Fodder....................tons..	....	....	268,932.3	264,682	.66
Lupines:					
Seed....................tons..	161,112.8	398,110	107,858.4	106,154	.27
Fodder....................tons..	....	....	195,025.6	191,944	.48
Potatoes (*c*)....................bushels..	2,916,333.4	7,206,260	27,958,642.8	1,027,110,015	142.5
Beets for forage....................tons..	377,842.8	933,650	6,991,974.4	6,792,899	7.38
Other field roots (*d*)....................do...	467,804.0	1,155,944	3,549,766.7	3,493,668	3.02
Oil-seeds (*e*)....................do...	133,240.0	329,236	155,791.5	153,329	.47
Hops....................do...	47,390.5	117,102	33,201.1	32,676	.28
Clover seed....................bushels..	77,214.3	190,797	15,343.5	563,771	3.0
Clover hay....................tons..	1,795,429.5	4,436,506	5,258,909.4	5,185,642	1.17
Lucern hay....................do...	191,337.3	472,794	768,128.0	755,989	1.60
Esparcet hay....................do...	107,575.3	265,819	323,544.7	318,432	1.20
Other forage plants (*f*)....................do...	445,851.2	1,101,698	948,265.1	933,279	.85
Meadow hay....................do...	5,903,286.0	14,587,020	15,884,187.1	15,633,160	1.07

a Metric tons are reduced to bushels, at the rate of 60 pounds per bushel for wheat, 56 pounds for rye, 48 pounds for barley, 32 pounds for oats, 60 pounds for spelt, 60 pounds for einkorn, 50 pounds for buckwheat, 60 pounds for peas, 60 pounds for beans, 60 pounds for cloverseed.
b A variety of spelt.
c Including diseased ones to the amount of 3 per cent. of the whole product.
d Carrots, turnips, &c.
e Rape-seed, &c.
f Serradella, &c.

The area devoted to wine production the same year was 120,484.6 hectares (297,717 acres), and the product was 3,727,366 hectoliters (98,465,828 gallons).

SWEDEN.

The following table shows the produce of the principal crops of Sweden for the years 1886 and 1885, with the average produce for the ten years 1875–'84. The quantities, as expressed in hectoliters, are from the summary statements of the crops of the year, issued by the Central Statistical Bureau of Sweden for the years 1886 and 1885, respectively:

Products.	1886.		1885.		Annual average for 1875–'84.	
	Hectoliters.	*Bushels.*	*Hectoliters.*	*Bushels.*	*Hectoliters.*	*Bushels.*
Wheat	1,339,600	3,801,115	1,380,300	3,916,601	1,165,400	3,306,823
Rye	7,144,800	20,273,370	8,092,900	22,963,604	6,882,200	19,528,243
Barley	5,659,500	16,058,831	4,781,000	13,566,088	5,527,100	15,683,146
Oats	19,394,200	55,031,043	18,284,000	51,880,850	18,394,800	52,195,245
Buckwheat	3,100	8,796	2,700	7,661	3,700	10,499
Mixed grain	2,698,600	7,657,278	2,237,100	6,347,771	2,123,900	6,026,566
Legumes	1,032,200	2,928,868	978,100	2,775,359	997,700	2,830,974
Colza	1,200	3,405	8,300	23,551	8,000	22,700
Potatoes	17,850,400	50,650,510	18,612,400	52,812,685	18,056,000	51,233,900

AUSTRIA.

The Austro-Hungarian Ministry of Agriculture has recently issued Part I of the Statistical Year Book for 1885, containing the final official statistics of agricultural production in Austria for that year. The area and produce of the principal crops are given below, both in Austrian denominations, as stated in the document named, and in their equivalent units of American measure and weight:

Products.	Areas.		Produce.	
	Hectares.	*Acres.*	*Hectoliters.*	*Bushels.*
Wheat	1,194,059	2,950,520	17,015,680	48,281,992
Spelt	6,510	16,086	100,790	285,992
Rye	1,994,461	4,928,313	27,883,690	79,119,970
Barley	1,166,416	2,882,214	18,344,870	52,053,569
Oats	1,829,047	4,519,575	33,389,650	94,743,132
Maize	367,657	908,480	7,008,060	19,885,370
Millet	76,150	188,166	1,047,686	2,972,809
Sorghum	4,438	10,966	47,610	135,093
Legumes	....	....	2,635,145	7,477,224
Mixed grain	20,869	51,567	372,990	1,058,359
Buckwheat	220,119	543,914	2,412,360	6,845,072
Rape seed, &c.*	....	....	570,000	1,617,375
Clover seed	69,733	172,310	....	....
Potatoes	1,097,872	2,712,842	129,737,065	368,128,922
			Met. cent.	†*Tons.*
Straw	....	....	129,963,600	12,790,971.1
Flax	85,717	211,807	429,951	42,315.6
Hemp	43,569	107,659	231,849	22,818.5
Tobacco	1,865	4,608	25,178	2,478.0
Chrysanthemum	616	1,522	10,210	1,004.9
Chicory	266	657	24,340	2,395.5
Sugar beets	148,768	367,606	25,373,370	2,497,238.0
Turnips	....	....	20,346,860	2,002,530.7
Pumpkins	....	....	1,431,900	140,927.1
Hay, clover	782,844	1,934,408	21,931,365	2,158,477.1
Hay, grass ‡	....	....	71,994,510	7,085,674.0
Vetches, green corn, and mixed fodder	....	....	3,702,240	364,373.1
Hops	12,775	31,567	58,044	5,712.7
Olive oil	44,663	110,362	120,693	11,878.6
Chestnuts	....	....	22,987	2,262.4
Figs	....	....	36,072	3,550.2
Other fruits and nuts	....	....	6,129,490	603,262.2
			Hectoliters.	*Gallons.*
Wine	228,940	565,733	4,000,850	105,690,454
				Head.
Cabbage	76,100	188,043	....	908,126,000
Teasel	514	1,270	....	72,440,000

* The area of rape alone was 40,649 hectares, or 100,444 acres.
† 2,240 pounds.
‡ The area in meadows is stated at 2,937,248 hectares, and that in mountain grass land at 134,037 hectares, making a total of 7,589,195. What part of this area is cut for hay is not stated.

HUNGARY.

The following statement, showing the area and produce of the prinipal crops of Hungary for 1885, and their average area and produce for the ten years 1876–1885, is compiled from the *Statistisches Jahrbuch*, published by the Hungarian bureau of statistics, Hungarian denominations being reduced to their American equivalents:

Crop.	Area. 1885.	Area. Average for 1876–'85.	Product. 1885. Total.	Product. 1885. Per acre.	Product. Average for 1876–'85. Total.	Product. Average for 1876–'85. Per acre.
Wheat:	*Acres.*	*Acres.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Winter	6,354,354	5,881,817	108,516,470	17.1	85,325,081	14.5
Spring	417,893	425,114	5,288,989	12.7	4,765,358	11.2
Total	6,772,247	6,306,931	113,805,459	16.8	90,090,439	14.3
Rye:						
Winter	2,693,951	2,818,033	40,370,880	15.0	37,849,949	13.4
Spring	100,874	86,324	1,338,795	13.2	1,071,103	12.4
Total	2,794,825	2,904,357	41,709,675	14.9	38,921,052	13.4
Spelt	9,343	9,032	163,905	17.5	127,652	14.1
Mixed grain	458,059	533,484	7,215,059	15.8	7,293,554	13.7
Total bread grains	10,034,474	9,753,804	162,894,099	16.2	136,432,697	14.0
Barley:						
Winter	198,172	147,977	4,341,801	21.9	2,579,077	17.4
Spring	2,386,170	2,289,716	49,971,383	20.9	40,262,499	17.6
Total	2,584,342	2,437,693	54,313,184	21.0	42,841,576	17.6
Oats	2,565,414	2,611,330	54,442,627	21.2	51,770,135	19.8
Millet	72,801	109,718	1,199,289	16.5	1,611,633	14.7
Buckwheat	46,976	46,769	688,707	14.7	490,319	10.5
Vetches (seed)	149,881	107,592	2,274,844	15.2	1,453,914	13.5
Peas, lentils, and beans	105,581	99,710	1,407,133	13.3	1,144,890	11.5
Maize	4,633,869	4,615,171	109,093,093	23.5	86,301,458	18.7
Potatoes	1,036,881	1,024,954	109,548,489	105.7	85,380,130	83.3
Rape-seed:						
Winter	211,987	234,272	1,927,131	9.1	2,415,940	10.3
Spring	22,956	10,744	163,505	7.1	110,171	10.3
Total	234,943	245,016	2,090,636	8.9	2,526,111	10.3
Flaxseed	....	....	250,531	....	207,425	....
Hempseed	....	....	2,219,921	....	1,628,165	....
			Tons.	*Tons.*	*Tons.*	*Tons.*
Flax fiber	27,095	25,938	4,043	.15	4,647	.18
Hemp fiber	165,520	170,192	40,804	.25	42,100	.25
Tobacco	140,573	155,427	61,398	.44	60,783	.39
Sugar-beets	78,432	77,301	586,008	7.47	555,829	7.19
Turnips	225,429	166,717	2,102,645	9.33	1,345,572	8.07
Lucern, clover, and sainfoin	552,459	459,799	772,248	1.40	601,712	1.31
Vetch mixture, millet-grass, &c	514,781	394,303	590,063	1.15	420,478	1.07
Hay	6,330,139	6,694,868	4,935,295	.78	4,616,250	.69
Fallows	5,069,714	5,696,129	....	....	....	....

The value of the wine product was $18,804,546.

Exports of wheat from India.

Years.	Bushels.	Value.	Value per bushel.	Years.	Bushels.	Value.	Value per bushel.
1868	558,852	$493,015	$0 88	1878	11,896,580	$13,985,177	$1 17
1869	514,231	480,616	93	1879	1,972,544	2,531,252	1 28
1870	145,988	160,225	1 10	1880	4,109,495	5,471,245	1 33
1871	463,908	505,303	1 09	1881	13,896,167	15,952,105	1 15
1872	1,189,251	1,146,766	96	1882	37,148 543	43,163,723	1 16
1873	735,485	816,063	1 11	1883	26,495,024	29,631,213	1 12
1874	3,277,781	4,027,545	1 23	1884	39,202,636	43,291,464	1 10
1875	2,004,156	2,391,646	1 19	1885	29,538,311	30,736,902	1 04
1876	4,686,767	4,410,660	94	1886	39,312,969	38,943,436	99
1877	10,428,327	9,526,855	91	1887*	27,914,133	20,789,688	74

* Year incomplete.

CONCLUSION.

The increase of labor in volume and variety to meet the public requirements upon the statistical branch of this Department cannot be indicated fully in the annual report. This presentation is not a synopsis of the work done, much of which is special and specific, for current uses of individuals or bodies in legislative, administrative, and commercial work. Some of the more important original investigations of the year are here recorded, including, of course, the records of acreage, production, and value of some of the principal crops. There are other rural industries, less general in distribution or more complicated in their data, which are not included. The year is too short or the country too large to attempt a census monthly or annually of all products, which include those of nearly every climate or condition in the domain of general agriculture.

The work has the voluntary assistance of about twelve thousand local correspondents and helpers, and in the Washington office a clerical force of about sixty is employed. It is the constant aim to improve the service, in widening its range, in extending its facilities, and in increasing its accuracy and reliability, and especially its practical usefulness to the farmers of the United States.

J. R. DODGE,
Statistician.

HON. NORMAN J. COLMAN,
Commissioner.

REPORT OF THE ENTOMOLOGIST.

INTRODUCTION.

SIR: I have the honor to present herewith my annual report for the year 1886. It is confined to the consideration of a few prominent and important insects that have not before been fully treated of in Department publications, and I have omitted from it, because of the limitation as to number of pages allotted to the Entomologist, many briefer notes and articles that have been prepared as the result of the year's work. These omitted portions will at once be prepared for special bulletins.

The fruit interests of the Pacific coast have of late years been more and more threatened by injurious insects, and in the present report the leading place is given to the consideration of the Cottony Cushion-scale (*Icerya purchasi*), which is perhaps the greatest pest that the fruit-growers in that section have to contend with. I was urged last spring by many prominent horticulturists and by Hon. W. W. Morrow, M. C. from the fourth district of California, to personally visit the infested region, but as this was impossible then on account of impaired health and important duties in the East, Messrs. D. W. Coquillett and Albert Koebele were sent to Los Angeles early in the year, with instructions to carry on through the summer an extensive series of experiments and observations upon the species. It will be seen from the context that this is one of those insects which have, naturally, extremely limited powers of spreading, and that its introduction from one continent to another and its subsequent spread might easily have been prevented had vigilance and intelligent appreciation of the dangers of such an introduction prevailed in years gone by as they are beginning to prevail now. The article is supplemented by detailed reports on experiments by Messrs. Coquillett and Koebele, which indicate the difficulties of controlling the pest, but at the same time show that these difficulties may be overcome.

The kerosene emulsions, in different proportions, which have proved so entirely satisfactory against the scale-insects of the Orange in Florida, have in general failed to win the good opinion of orange-growers in California. Mr. Matthew Cooke and other writers in the latter State have pronounced the kerosene emulsions inferior to caustic soda and caustic potash, and even to strong solutions of whale-oil soap.

Until this year I have been unable to offset the decision of these gentlemen with the result of careful experiment, though I have always believed their want of success was due to imperfect preparation of the emulsions or imperfect application of them. I was also inclined to give some credence to the theory advanced by Prof. E. W. Hilgard, that the dryness of the atmosphere in California induced a more rapid evaporation of the kerosene in the emulsion, which accounted for its inferior results. Moreover, the Cottony Cushion-scale is much less susceptible to the action of insecticides than any Floridian species on account of the protection afforded by the large waxy mass which it secretes, as well as on account of its great vitality.

The detailed reports on remedies just referred to show that kerosene emulsions must still be placed at the head of the list, not only for ordinary scale-insects, but for this *Icerya*, so far as efficacy is concerned, though other remedies have the advantage of being cheaper. In the proportion of 1 part of the soap emulsion to 15 parts of water it proves a perfect remedy for their Red Scale (*Aspidiotus aurantii*), a species which has done incalculable damage in Australia and has created much alarm in California. After a thorough application of the mixture in March Mr. Coquillett found that every scale-insect was killed, and at the expiration of two months all had dropped from the leaves. Used in the same proportion on the Cottony Cushion-scale, however, it does not kill the old females with the egg-masses, nor all of the eggs. Used at twice this strength it kills all of the eggs, as well as the old females, and even when properly used at the rate of 1 part of the emulsion to 5 parts of water it leaves the tree uninjured.

Mr. Coquillett reports, with reference to the much-praised caustic soda, that it has no effect on the eggs of the *Icerya*, even when applied so strong as to burn the bark brown and kill all the leaves. Similarly, whale-oil soap, one pound to two gallons of water, does not kill the eggs directly, nor does hard soap and water in the same proportions, although the effect of the latter seems greater than that of the former. They both, however, harden the egg-masses so that a large proportion of the young larvæ are unable to escape. The experiments add greatly to the value of ordinary tobacco, for one of the most effectual washes used is made by boiling one pound of tobacco leaves in one gallon of water until the strength has been extracted from the leaves, and then adding enough water to make two gallons. This wash, however, costs about 5 cents per gallon, and is too expensive for ordinary use. Mr. Koebele, experimenting through August, September, and October, found that kerosene emulsified with soft-soap penetrates the egg-sacs well, kills the old scales, and leaves the tree uninjured. Emulsions of crude petroleum, although much cheaper, he found very apt to injure the trees. He devoted his chief attention, on account of their great cheapness, to the preparation of soaps and resin compounds. He succeeded in making a number of these mixtures, which, when properly diluted, need not cost more than from one-third to one-half of a cent per gallon, and which, if thoroughly applied, will bring about very satisfactory results, killing the insects and either penetrating or hardening the egg-masses so as to prevent the hatching of the young. I am strongly of the opinion that the value of the soap washes depends somewhat on the season of their application, and that the greater success of Mr. Koebele with them as compared with that of Mr. Coquillett was probably due to the fact that his experiments were made during the dry or rainless season.

In connection with the subject of kerosene emulsions, I may put on record here an important discovery made last spring in carrying on further experiments at the office in emulsifying this oil. It is that the white of eggs with a little sugar may be used as a satisfactory substitute for milk where this is not accessible.

If the white of 2 eggs, about 3 tablespoonfuls of sugar, $\frac{3}{4}$ quart of water, and $1\frac{1}{4}$ quarts of kerosene are worked through a force-pump and cyclone-nozzle for from 5 to 10 minutes a cream-like emulsion is produced, which can be diluted with water to any desired amount without any separation of the oil; provided that the emulsion is not allowed to stand for any length of time.

Another investigation that has occupied considerable of my time

lately is that in reference to the Southern Buffalo Gnats. The loss occasioned by the attacks of these upon domestic animals has been of late years very great, and the Division has been strongly appealed to by influential stock-raisers in the lower Mississippi Valley for information. Messrs. F. M. Webster, Otto Lugger, and Francis Fillion have each been directed to make special investigations and experiments during the year in different parts of the South, and Dr. Warren King, of Vicksburg, has aided in various ways. At the time when these investigations began the particular species concerned had not been determined; nor was anything known of their habits in the early stages. These habits were surmised from what was known of other species of the genus both in this country and Europe, which, as a rule, breed in clear, rapid, and rocky streams; but it was a question how our Southern species could breed so numerously in the lower alluvial Mississippi country.

It results from the investigation that there are more particularly concerned two species, which may be known and distinguished as the Southern Buffalo Gnat (the larger and more common of the species) and the Turkey Gnat, the names by which they are very generally known in the country affected. They are both undescribed species, and I have given them the names of *Simulium pecuarum* and *S. meridionale* respectively. The habits of both species are similar, and both have been found to breed in the more swiftly running currents of bayous and larger streams which are permanent and do not dry up in midsummer. The larvæ are found attached to the masses of drift-wood and leaves which form at points, and which, by impediment, induce a more rapid current on the surface. Very full details will be found in the article, and at its close I have discussed the bearing which seasons of overflow may possibly have on the increase of these insects. Much yet remains to be ascertained, however, especially as to oviposition, the eggs, and the early habits of the larvæ.

Another insect that will be found fully treated of is the common Fall Web-worm (*Hyphantria cunea*), which abounded during the past year in the Eastern States in a phenomenal way, and which was so destructive to the shade trees of the Capital as to attract an unusual share of attention and to call forth many requests for information. Many facts hitherto unpublished, both as to its habits and natural enemies, will be found recorded, while advantage has been taken of the very favorable opportunity afforded by the exceptional increase of the species in Washington City to carefully study its relative preference for different trees. I have already published in my report for the year 1883, and in Bulletin 6 of this Division, in considering the Imported Elm Leaf-beetle, full directions for protecting trees from leaf-devouring insects, and as it is inadvisable to repeat what is already accessible in published form, I have given but a brief summary of the means available for protecting trees from this Fall Web-worm. Moreover, the spraying appliances that are most useful against the scale-insects, and treated of in considering the Cottony Cushion-scale of California, are equally applicable here, and in so far as they differ from those already described and published in previous reports they will be found treated of in connection with said scale. So far as the city of Washington is concerned (and the same will apply to all cities) there can be little doubt that the great increase of this Fall Web-worm of late years has been largely due to two circumstances: First, the prevalence of the English Sparrow and its indisposition or inability to feed upon this worm, while making

more room for it by destroying other less injurious and smooth species; secondly, the use of the wooden tree-boxes, which afford such excellent winter shelter for the cocoons.

Some recent experience is recorded with regard to Joint Worms, and the interesting fact is brought out that alternation of generation occurs among them, and that in the genus *Isosoma*, to which they belong, two forms, which have hitherto been considered good species, are in reality seasonal dimorphic forms of one and the same species, as I have always suspected would prove to be the case.

The year 1886 may be said, entomologically, to have been an ordinary one, and notwithstanding the exceptional injury by some, there has been, perhaps, less damage than usual from injurious species.

Among these last must be mentioned the Hop Aphis (*Phorodon humuli*), which was so destructive in the great hop regions of New York State as to have caused an almost total loss. The best evidence I have been able to obtain from correspondents is that in a great many cases no harvest was made, and on an average only about 10 per cent. was harvested. In this connection I have taken steps to carry on a series of practical experiments the coming year, and I may state as a matter of interest that, from investigations made last September in the hop fields I am led to believe that I have discovered the winter egg of this hop-louse upon plum trees, so that its mode of hibernation, which has hitherto been a mystery, has thus been settled. Full verification of this fact, however, cannot be obtained without another season's observation, and for this reason I have been unwilling so far to publish anything in detail.

In my last report I showed that, so far as experiments in silk-culture are concerned, no decisive results could well be hoped for until the Serrell automatic reel could be tested at some point in Washington where the details could be well controlled and observations made by myself and assistants, and where the work could be carried on for at least two years. Congress therefore appropriated $10,000 for this particular purpose, and the reeling stations at San Francisco, New Orleans, and Philadelphia have been abandoned. The brief report of the work in this direction, which will be found in the following pages, must be looked upon as preliminary; for, while the figures given look somewhat discouraging, no fair and proper estimate can be made before another year. The confirmation which our reeling has so far given of the value of the Osage Orange as silk-worm food is interesting, and entirely in keeping with what I expected and what I have previously recorded.

Work has been continued at the apicultural station at Aurora, Ill., as far as the means would permit, and a report on some of the experiments by Nelson W. McLain, in charge of the station, is embodied, while some further reports will be included in a special bulletin. I have endeavored by occasional consultations with Mr. McLain to keep the experiments in lines that have been more or less neglected by bee-keepers and in which there was hope of valuable results. The most important of these are in the direction of controlling fertilization. Most of the improvement in bee-culture in the past has been in the direction of mechanical appliances, while these experiments have in mind the improvement of the bee itself, so as to increase its honey-yielding power, and thus advance the interest in the same way that the dairy interest has been advanced by improving the milk and butter producing qualities of the cow.

A year ago Congress added $5,000 to the appropriation of the Divis-

ion for the promotion of economic ornithology, and charged the Entomologist with carrying on the work. This appropriation was made at the instance of Professor Baird, myself, and Dr. C. Hart Merriam, and in obedience to a memorial from the American Ornithologists' Union. Work was begun by your appointing Dr. Merriam as a special agent in charge, and Dr. A. K. Fisher and a clerk to assist. The scope of the work planned was indicated in my last annual report, it being arranged that the part relating to food habits should be dealt with by myself and former associates because of its entomological bearing; while to Dr. Merriam was assigned all the other phases of the work, he being particularly interested in the migrations of birds as chairman of the committee on migrations of the Union above mentioned.

Early in July, 1885, a circular was prepared (Circular 20, Division of Entomology) setting forth the objects of the investigation, and asking information concerning the food-habits of certain well-known birds which were supposed to be beneficial or injurious to the farmer. About 2,000 copies of this circular were distributed to farmers and ornithologists throughout the country, and a large number of replies were received. During the winter two additional circulars (Circulars 24 and 27, Division of Entomology), accompanied by three schedules, were prepared, which related to the migration and geographical distribution of North American birds. These were sent to the keepers of light-houses along the coasts and lakes and to the regular observers of the American Ornithologists' Union.

Special attention was given during the year to the English Sparrow question, and a large amount of information has been collected. The ravages of birds in the rice fields of the South was another matter which early received attention, and Dr. Fisher was sent on an extended tour through the rice-growing districts, giving particular attention to those of Georgia and Louisiana. The formation of a collection of the stomachs, crops, and gizzards of birds was early undertaken, and has been continued to the present time.

From the outset I have recognized that while the ornithological work, so far as it related to food-habits, was legitimately placed in the Entomological Division, because of its intimate connection with the subject of entomology, yet there were many other lines of inquiry that have no particular bearing on entomology, and could not well be prosecuted in earnest without detracting from the time which should be devoted to the more legitimate sphere of the Division. As soon, therefore, as it was ascertained that there was some prospect of getting a new Division created I strongly urged such action, and a new Division of Ornithology and Mammalogy was created last June by Senate amendment to the House bill, it having been previously arranged that the Entomologist should take charge of the question of food-habits so far as they relate to insects. Unfortunately, however, the appropriation to the new Division was taken from the Entomological Division, thus reducing the means of this last below what it was two years ago, so that the work has been correspondingly crippled by the stoppage of investigations already begun (especially in California and the South), by the discharge of some of the employés and the reduction in salary of some of the others.

So much of the time devoted to ornithology during the year having been taken up in original investigations and the accumulation of material, Dr. Merriam has submitted no formal report, and the results

of the investigations, so far as they have been written up, will be published directly under the new Division.

In this connection, as evidence of the interest abroad in applied entomology, I would refer to the holding of an international exhibition of machinery and contrivances for applied remedies against fungi and insects that are destructive to cultivated plants. This congress was held in October at Florence, and his Excellency, B. Grimaldi, the minister of agriculture, industry, and commerce for Italy, was very anxious to have the Division represented by such discoveries and mechanical appliances as have been developed in its work of late years. He was also very anxious to have a representative from the Department to take part in the discussions of the congress to be held in connection with the exhibition. The Entomologist was in fact made one of the jurors, and it is to be regretted that, by the terms of our appropriation, the Department was unable to have entomological representation at said congress. From reports of the congress that have come to hand, kindly furnished by Prof. Gustav Foëx, in charge of the experimental school of agriculture at Montpellier, and of Henri Grosjean, of Paris, it is evident that they have made good use of the remedies and contrivances published and recorded in our annual reports, and that, with the exception of experience against the Grape-vine Phylloxera, there was not very much that would have interested us in America.

The work of the Division is best represented by its published results, as, after all, its value is proportioned to the manner in which it is placed upon record and made available to the public, though there is of necessity a great amount of work that is not accounted for in print. In the matter of published and contemplated reports and bulletins, the following list represents the activity of the Division fairly well:

The publications of the present year have been as follows:

Bulletin No. 8. The Periodical Cicada. An account of Cicada septendecim and its tredecim race, with a chronology of all broods known. pp. 46.

Bulletin No. 11. Reports of Experiments with Various Insecticide Substances, chiefly upon insects affecting garden crops. pp. 34.

Bulletin No. 8. Second edition.

Insects affecting the Orange. Report by H. G. Hubbard on the insects affecting the culture of the Orange and other plants of the Citrus family, with practical suggestions for their control or extermination. pp. 227; figs., 95; plates, 14.

Fourth Report of the United States Entomological Commission, by C. V. Riley, being a revised edition of Bulletin No. 3, and the final report on the Cotton Worm, together with a chapter on the Boll Worm. pp. 546; figs., 45; plates, 64.

Report of the Entomologist for the year 1885. pp. 154; plates, 9.

Bulletin No. 12. Miscellaneous Notes on the Work of the Division of Entomology for the season of 1885. pp. 45; 1 plate.

Bulletin No. 9. The Mulberry Silk-worm; being a manual of instructions in silk-culture. Sixth revised edition of Special No. 11. pp. 62; figs., 29.

Those in course of preparation are:

Final Report on Insects injurious to Forest Trees (nearly completed).

Bibliography of Economic Entomology. A critical list of the economic writings of American entomologists.

Report on Insects affecting Domestic Animals.

Report on Remedies. A critical and classificatory treatise upon all the remedies which have been recommended against injurious insects.

Report on the Insects affecting Garden Crops of Florida.
Report on the Insects affecting the Grains.
Report on Insects affecting the Hop Crop.
Report on Insects affecting the Cranberry Crop.
Report upon the Grape-vine Phylloxera.
Monograph of the Acrididæ (destructive Grasshoppers).
Monograph of the Noctuidæ (Cut-worms, &c.).
Bulletin on Acronyctas (destructive tree-caterpillars).
Report on the Insectivorous Habits of Birds.
Several bulletins.

Dr. Packard has continued work on the Report on Forest Insects. He spent a portion of March and April in Northern and Central Florida studying and collecting the species injurious to Live and Water Oak, as well as to the Pines and Cypress. His observations go to corroborate those of others who have studied the Florida insect fauna, viz, that while a large proportion of the insects feeding on the oaks in Central Florida differ from those found in the Northern States, yet the pine insects from Maine to Florida belong to nearly one and the same fauna. During the summer months he worked in Maine, on the shores of Casco Bay, and a considerable amount of work was also done near Jackson, in New Hampshire, and around Providence. A report by him on some of the insects observed, and especially on a worm injurious to spruce buds, has been submitted, and will be published in the next bulletin.

Mr. F. M. Webster has continued investigations on the insects affecting our grains and forage plants, and his report, included herewith, contains a number of interesting observations, and also a list of 102 species of insects frequenting Buckwheat, with notes of their relative abundance and their method of attacking the plant.

Mr. Lawrence Bruner has continued work in Nebraska, and a special report from him will be published in bulletin form.

Prof. Herbert Osborn, of Ames, Iowa, has continued to assist me in work upon the insect parasites of domestic animals.

Miss M. E. Murtfeldt and Mr. J. G. Barlow were each engaged during the year for brief periods in various observations in Missouri, and Mr. William H. Ashmead similarly for a brief period in Florida.

Work by Mr. B. P. Mann on the Bibliography of Economic Entomology has been interrupted by the reduction in the appropriation, but otherwise the Divisional force at the Department remains the same, Messrs. E. A. Schwarz and Theo. Pergande assisting in the office work.

The illustrations to this report have been made by Miss Lillie Sullivan and Dr. George Marx, with the supervision of myself or of Mr. Howard.

I take pleasure, in conclusion, in acknowledging my indebtedness to Mr. Otto Lugger for assistance in the preparation of the article on the Buffalo Gnats and for the satisfactory manner in which he carried on his observations at Memphis, and particularly to Mr. L. O. Howard, who has had charge of the Division during my absence, and who has materially assisted me throughout both in the office correspondence and the preparation of reports. December 24, 1886.

Respectfully submitted,

V. RILEY,
Entomologist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

MISCELLANEOUS INSECTS.

THE COTTONY CUSHION-SCALE.

(*Icerya purchasi* Maskell.)

Order HEMIPTERA; family COCCIDÆ.

[Plates I, II, III, IV, and V.]

INTRODUCTORY.

We have, during the year, been conducting a special investigation of the habits of and remedies for the so-called Cottony Cushion-scale of California, an insect which for the last eight years has occupied much of the attention of the horticulturists of that State. We have been much interested in this pest since it was originally sent to us while in Missouri by Mr. R. H. Stretch from San Francisco in 1872, and have watched its increase and spread, until it became evident from its alarming prolificacy, from the great diversity of its food-plants, from its supposed immunity from the attacks of natural enemies, and from the protection against the action of insecticides afforded by its abundant waxy excretions, that especial study and experiment were much needed.

The following account of the insect is prepared from published accounts and unpublished correspondence; from our biologic notes made at the office in Washington, chiefly in 1878, 1880, and 1886; but more especially from our recent experience in the field (which the delay in publishing the report has enabled us to partly embody), and the observations of Messrs. Coquillett and Koebele, whose reports on experiments made to destroy it will be found given in full among the reports of agents.

GEOGRAPHICAL DISTRIBUTION.

So far as we have been able to learn, up to the date of present writing, the Cottony Cushion-scale is found only in California, in Australia, in South Africa, and in New Zealand. We shall discuss its introduction into California and its present limitations in that State in subsequent sections of this paper, and what we know of its spread in the other countries mentioned is here considered.

IN AUSTRALIA.—As will appear farther on, the evidence collected goes to prove that this insect is indigenous to Australia and has been exported from this colony to the two other colonies in which it occurs and to the United States. We have very few facts as to its occurrence in Australia and these are taken at second hand. We have addressed communications to a number of naturalists in different portions of that country, but their replies have at this writing not been received. From the "Report of the Commission appointed by his excellency the governor to inquire into and report upon the means of exterminating the insect of the family '*Coccidæ*,' commonly known as the 'Australian Bug,'" published at Cape Town, 1877, and from the letter of Mr. Roland Trimen, dated February 5, 1877, and published by the government secretary of Cape Colony as "Government Notice No. 113, 1877," we find that at that time specimens of the insect were sent from Cape Town to different portions of Australia, and that re-

plies were received as follows: The Queensland authorities simply promised inquiry and report. The government of South Australia did not recognize the insect in question as a native of that colony. The inquiry to Victoria was referred to Prof. Frederick McCoy, director of the National Museum at Melbourne, who identified the insect as a new *Dorthesia*, "common in Victoria on different kinds of *Acacia*."

This is the extent of our information. Mr. Maskell, in his second paper on this species (Transactions and Proceedings New Zealand Institute, XIV, p. 226, 1881), writes: "When in Australia a few months ago I observed at Ballarat an insect, certainly an *Icerya*, but I think not *I. purchasi*; but I had no opportunity of bringing away a single specimen." There exists, then, a possibility at least that the insect under consideration is found at Ballarat as well as around Melbourne.

IN CAPE COLONY.—We find in the "Report of the Commission," &c., just cited, the following information on the spread of the insect in this colony:

From the answers received it would seem that the insect, having first appeared and succeeded in establishing itself in Cape Town and the vicinity, gradually spread along the lines of traffic by land and sea to different parts of the colony; and we may mention, in evidence of its irregular dispersal by chance methods of conveyance, that it was observed in the village of Ookiep, Namaqualand, only a few months after its first discovery in the Cape Town Botanical Gardens in 1873, and yet was not seen in the neighboring division of Stellenbosch till the later end of 1876.

The limits to which the insect had extended at the time of the publication of the report of the commission (1877, presumably the latter part of the year) included the following localities: Cape Town and neighborhood, Simon's Town, Stellenbosch (Mulders Vlei), Malmesbury, Paarl, Wellington, Namaqualand (Ookiep), Bredasdorp, George (Brak River), Uitenhage, East London.

We have no information as to the present status of the insect in this colony, as the replies to our letters of inquiry have not yet come to hand.*

IN NEW ZEALAND.—From the paper containing Mr. Maskell's original description of *Icerya purchasi* (Trans. and Proc. N. Z. Inst., XI, 220, 1878), we learn that the insect was first noticed at Auckland. A note by Mr. E. A. MacKechnie (Ibid., XIV, 549, 1881) indicated that it had greatly increased in presumably the same neighborhood in 1881. In Mr. Maskell's second paper (Ibid., p. 226) he mentions in a foot-note that he had just received the insect from Napier. In his third paper (Ibid., XVI, 140, 1883) he writes as follows:

Icerya purchasi has spread greatly in the last two years. It had just reached Napier at the date of my last paper. It has now established itself in that district not only in gardens, but in the native forests. In Auckland it is attacking all sorts of plants. * * * It has reached Nelson, and I have had many communications from that place complaining of its ravages. * * * Whether this pest will spread in our colder southern climate (Christchurch) as it has in the warmer north remains to be seen. Our gardeners here are not in much dread of outdoor insects; they confine their attention to those in greenhouses. They may be right; still the winter even in Canterbury is not severe enough to kill these insects, and I know that in the Christchurch public gardens many trees have had to be burnt simply on account of the ravages of *Coccidæ*.

We have no information on this point from this colony later than 1883, but have taken steps to ascertain the present spread of the pest.

*Just as the report is being sent to the printer we learn from Miss Ormerod that she has received specimens from Port Elizabeth, Cape Colony.

IMPORTATION OF THE SPECIES INTO CALIFORNIA.

The first printed record, with which we are acquainted, of the occurrence of the Cottony Cushion-scale in California is Mr. Stretch's article in the Proceedings of the California Academy of Sciences, Vol. IV, read September 16, 1872. In opening this paper he refers to the fact that "at a former meeting certain insects forwarded to this society from Menlo Park, San Mateo County, by Mr. Gordon," were referred to him for examination. A careful search through the previous proceedings fails to show any mention of this previous sending, though at the meeting of July 1, 1872, Mr. John Hewston, jr., "exhibited some limbs of Australian Acacia from San Mateo which were infested by a species of Coccus, and stated that the insect had not only been detected in its depredations upon said tree, but also upon the orange trees." This latter reference may very possibly have been to the Cottony Cushion-scale, and if so it is interesting, as indicating already a spread of some miles from Menlo Park.

All the slight evidence possessed points to the introduction of this scale on Australian Acacia by Mr. George Gordon about 1868 or 1869. Mr. Stretch says:

> This being all the information to be derived from the specimens referred to me, I visited Menlo Park in search of further information, and received a very hearty welcome from Mr. Gordon. The supposition is that the insect was imported from Australia some three years ago; at any rate it seemed to originate on the *Acacia latifolia*.

This was evidently Mr. Gordon's supposition, and the plain inference is that about three years previous to this time certain Acacias had been imported by Mr. Gordon from Australia as plants or cuttings contrary to the general custom, although it is not stated in so many words.

Dr. A. W. Saxe, of Santa Clara, Cal., in 1877, wrote:*

"So far as I can ascertain, it was brought to California on some plants imported from Australia by the late George Gordon, of Menlo Park (the sugar refiner)."

In the introduction to our annual report as Entomologist to this Department for 1878 we referred to the serious complaints that came from the Pacific coast of injury by it to orchard and ornamental trees, and from specimens received from Dr. Saxe (Mr. Maskell's papers being unknown here then) referred it to the genus *Dorthesia*, and remarked:

> It is an Australian insect, and has of late years been introduced on Australian plants into South Africa, where, as I learn from one of my correspondents, Mr. Roland Trimen, curator of the South African Museum, it has multiplied at a terrible rate, and become such a scourge as to attract the attention of the government. It has evidently been introduced (probably on the Blue Gum or *Eucalyptus*) to California, either direct from Australia or from South Africa, and will doubtless become quite a scourge; because most introduced insects are brought over without the natural enemies which keep them in check in their native country and consequently multiply at a prodigious rate. It will be naturally partial to Australian trees, and shows a preference for Acacia, Eucalyptus, Orange, Rose, Privet, and Spiræa.

Professor Comstock, in the Annual Report of the Department of Agriculture for 1880, p. 348, cited this article of Dr. Saxe's as the earliest article with which he was acquainted, and repeated Dr. Saxe's opinion as to the introduction of the insect.

Beyond this we are able to get no information upon the subject, and these data are in all probability the first connected with the introduction of the Cottony Cushion-scale. There may possibly have been

* *California Agriculturist and Artisan*, December, 1877.

subsequent and independent importations, but that this is the one from which the main spread originated there can be little doubt.

ITS SPREAD AND PRESENT LIMITATION IN CALIFORNIA.

We are indebted to Mr. Matthew Cooke, of Sacramento, for communicating a lengthy and careful account of the localities in which the pest at present exists in California. Mr. Cooke has mapped out ten districts, six in the counties of Marin, San Mateo, Santa Clara, Sacramento, Sonoma, and Napa, in the San Francisco region, and four in the counties of Santa Barbara and Los Angeles, in the southern portion of the State.

The first infested district extends from Menlo Park to San Mateo, a distance of 10 miles. It is bounded on the east by the Southern Pacific Railroad, and extends some 3 miles west, including in consequence some 30 square miles. But little effort, according to Mr. Cooke, has been made to eradicate the pest in this district.

The second infested district is contained within the town limits of San Rafael, Marin County, about 14 miles north of San Francisco. In this district it has been held in check, but there are still some to be found, and its increase is only dependent upon a lapse of vigilance.

The third infested district includes the city of San José and the town of Santa Clara, and contains an area of about 16 square miles. In these towns the scale insects infested the ornamental and shade trees and shrubbery, but did not seem to trouble the deciduous fruit trees to any extent. At San José energetic measures have been taken; the trees have been cut back and their trunks scrubbed until the pest has been thoroughly eradicated. At Santa Clara, however, little has been done, and some places are seriously infested.

The fourth infested district occurs at the city of Sacramento, where only about 120 acres are infested, although it is stated to be rapidly spreading. The insect was first discovered in this district by Mr. Cooke in October, 1885, in about eight gardens. The city trustees appropriated $200, and with this sum it was destroyed, except upon certain premises which the authorities could not enter. Mr. Cooke gives in this connection, as an instance of the rapidity of the multiplication and spread of the insect, the following:

> In October, 1885, a patch of these insects covered a space of about 3 by 4 inches was noticed upon a limb of an Acacia tree. From these it spread, and in a little more than a year several Orange and Lemon trees and other plants growing closely in an area of about 160 by 80 feet had become seriously infested.

The fifth infested district is found at Healdsburg, Sonoma County, about 65 miles north by west of San Francisco. Here the insect is mainly comprised within the town limits, and infests the shade trees along the streets and the shrubbery in the gardens.

In Mr. Cooke's sixth district the insect cannot be said to exist at present. It comprises a single garden in the town of Saint Helena, Napa County, about 60 miles north by east of San Francisco. It was found upon a rose bush in that place by Mrs. Richard Wood in October, 1882. The bush was destroyed, and the pest has not been found in that section since.

The seventh infested district includes the city of Los Angeles, where the insect is principally confined, according to Mr. Cooke, to the gardens and suburbs on the eastern side of the city. Mr. Coquillett says that as nearly as can be ascertained the insect was first introduced

into Los Angeles in 1878 upon some nursery trees purchased from a San Francisco nurseryman. These trees were planted in a certain nursery, and when the insects were first noticed upon them the owner was requested to burn them. He neglected to do this, and soon after failed in business, and the nursery fell into other hands. The new owner also proved indifferent, and from this point the insects spread into the surrounding orchards, going mainly in the direction of the prevailing winds. Some years ago a tree was found infested at Passadena, 7 miles east of Los Angeles, but it was immediately destroyed, and the insect has not been heard of since. At Pomona, 32 miles east of Los Angeles, the same thing happened in 1883. Two trees were found to be infested and were immediately destroyed, and the insect has not appeared since.

The eighth infested district is at Anaheim, Los Angeles County, 27 miles south by east of Los Angeles. Here the insect is purely local and does not seem to be spreading.

The ninth district is at San Gabriel, 9 miles east of Los Angeles. In the vicinity of this place are some of the largest orange groves in California. In 1880 or 1881, according to Mr. Cooke, a Mrs. McGregory bought a pot-plant in Los Angeles, brought it home, and placed it beside a small Orange near her house. In 1882 the neighboring orange trees were found to be infested with the Cottony Cushion-scale. In the fall of 1883 it was found in some of the larger orchards so abundantly as to cause alarm among the growers. By means of a voluntary tax of five cents per tree, some fifteen hundred or two thousand dollars were raised and expended and the pest eradicated. The most radical measures were used. The trees were cut back to the crotches, the branches burned, and the trunks scrubbed. In 1885, however, the insect was again found, but only in a few trees.

The tenth and last district includes the orchards in and around the city of Santa Barbara. According to Mr. Coquillett the scale was introduced into this district in 1878. A number of trees from the same lot which first introduced the pest into Los Angeles was sent to Santa Barbara at about the same time. Mr. Cooke states that he visited this district in July, 1884, and found Mr. Stowe's orchards (10 miles north of the city of Santa Barbara) the most seriously infested spot in the State. Forty acres, principally of lemon trees, were badly damaged, and over many acres the trees had been dug out and burned. Two miles north of Mr. Stowe's, Colonel Hollister's groves also contained the insect in numbers. About 40 acres were partially infested. The latter gentleman made strong endeavors to rid his groves of the insect, and spent a great deal of money, with only partial success. Mr. Cooke states that the course of the insect between Mr. Stowe's and Colonel Hollister's could be plainly traced over a rolling grazing land on the nettles, dock, and other weeds.*

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*Reports have gained currency that this Icerya was found abundantly around Santa Barbara on wild plants, and especially upon the "Grease-wood," and it has been argued from such reports that the species is indigenous. They have no foundation except in mistaken identity, a large Coccid belonging to the genus *Rhizococcus*, which occurs abundantly on *Artemisia californica*, having undoubtedly given rise to the report. The female of this species, which we shall describe as *Rhizococcus artemisiæ*, secretes a globular mass of white cottony wax, which is more or less distinctly ribbed, and her eggs are of the same color as those of the Icerya; but with these superficial resmblances which have misled, there are profound structural differences.

FOOD-PLANTS.

Original Food-plant of Icerya purchasi.—There seems good reason to believe that this species is originally an Acacia insect, and that upon one or another of the plants of this genus it was imported from Australia into South Africa, California, and New Zealand. Australia is pre-eminently the home of the Acacias, while none are indigenous to California, nor, so far as we can ascertain, to New Zealand, and, as is well known, the species now found in these two countries have been introduced from Australia.

Professor McCoy, of Melbourne, in his original communication to the government of Cape Colony, in 1876, stated that the insect in question occurred in Victoria on "different kinds of Acacia."

Mr. J. C. Brown* states, on the basis of Mr. Trimen's description, that the "Australian Bug" appears to resemble in several details one of the Coccidae found on the Kangaroo Island Acacia, universally around Adelaide. This statement is so indefinite as to have little weight; yet there is more than a possibility that the Australian insect mentioned is the *Icerya.*

Mr. Trimen, in his report previously mentioned, states that the first specimens seen by him in Cape Colony occurred in 1873, at Clairmont, on Blackwood trees (*Acacia melanoxylon*), obtained from the botanic gardens at Cape Town. He goes on to say:

> In the course of a few months the insect increased so prodigiously in number, and the Australian Acacias became laden with them to such an extent, that in the early part of 1874 the large Blackwood trees in the gardens, which were infested to a greater extent than any other plant, had to be cut down.

In New Zealand the first appearance of this insect was also upon an Australian Acacia. Mr. Maskell, in originally describing the insect, in 1878, says: "My specimens of this subdivision were found on a hedge of the Kangaroo Acacia,† in Auckland, in March last. I understood from Mr. Cheeseman and Dr. Purchas, who kindly brought this insect under my notice, that it had only lately appeared in Auckland, and that it was only as yet to be found upon that one hedge."

In California the experience was almost precisely similar. Mr. Stretch, in his paper before the California Academy of Sciences, in 1872, stated that at Menlo Park "it seemed to originate upon *Acacia latifolia,* a species imported from Australia." Miss Anna Rosecrans, writing to the *Pacific Rural Press* of February 17, 1877, says: "It was first noticed at San Rafael on Acacia trees four or five years ago." Dr. Chapin, in the first report of the State Board of Horticultural Commissioners of California, 1882, says: "This scale has been, it is asserted, known to be on the Acacia for seven years in San José, but it is only during the past and present seasons that it has attracted attention" (presumably by its spread to other cultivated plants).

Thus we have much cumulative evidence that the species of the genus Acacia are the preferred food-plants of the Cottony Cushion-scale, and, admitting Australia as its proper home, they are probably its original food.

Its Food-plants in South Africa.—From Mr. Trimen's 1877 report we gather the following list of plants to which the Australian Bug had spread since 1873:

Acacia melanoxylon.

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*On the "Australian Bug" of South Africa. *Journal of Forestry,* May, 1882. VI, p. 44.

†*Acacia armata.*—C. V. R.

Australian Acacias.
"Golden Willow."
Casuarius.
Pittosporum.
"Blue Gum" (rarely).
Australian "Bottle-brush."
Oak.
Orange.
Vine.
Fig.
Laurustinus.
Rose.
Rosemary.
Strawberry.
Verbena.
Plumbago.
Indian Jasmine.
Bougainvillea.
Hawthorn.
Poinsettia.
Hakea.

This list is not added to in the "Report of the Commission," &c., published at Cape Colony in 1877. Mr. Trimen, in the article cited above, gave the preference to the trees and shrubs of Australian origin; but Mr. J. C. Brown (*loc. cit.*) quotes him as writing, under date of March 17 (1882?), that the insect had then mainly attached itself to the orange trees. "Many of the finest plantations have been destroyed and others are on the high road to destruction. You will remember," he says, "how good and cheap oranges used to be here; they have lately been three pence and four pence apiece, and often inferior in quality even at such a price."

ITS FOOD-PLANTS IN NEW ZEALAND.—From the various communications of Mr. Maskell and others in the Transactions and Proceedings of the New Zealand Institute we give the following list of plants which have been especially designated. There has been no attempt, however, on Mr. Maskell's part to give at all a complete list, and in fact, he says,* "In Auckland it is attacking *all sorts* of plants, from Apple and Rose trees to Pines, Cypress, and Gorse":

Common Furze.
Orange.
Lemon.
Acacia decurrens.
Acacia armata.
Apple.
Wattles.
Rose.
Gorse.
Pine.
Cypress.

ITS FOOD-PLANTS IN CALIFORNIA.—Originally starting upon *Acacia latifolia* at Menlo Park, this insect soon spread to numberless other plants. Dr. Saxe, in 1877, mentioned that it already attacked the Acacias, Australian Pea-vine, Rose, Honey-suckle, Ivy-geranium, Laburnum, Pear, and the weeds in the orchard.

*Ibid., XVI, p. 140 (1883).

Dr. Chapin, in 1883, mentioned the following:
Pear.
Apple.
Bridal-wreath.
Rose.
Dwarf Box.
Verbena.
Veronica.
Acacia mollissima.
Acacia latifolia.
Acacia limnœris.
Acacia floribunda.
Pittosporum tobria.
Strawberry.
Black Locust.
California Laurel.
Cork Elm.
English Ivy.
Magnolia grandiflora.
White Oak.
Dwarf Flowering Almond.
Wild Grease-wood.

Our recent experience in California, as well as that of Messrs. Coquillett and Koebele last summer, would indicate that, while there are few plants upon which the insect will not temporarily feed if it happen to fall upon them while in the first stage, yet the number of plants upon which it can thrive and multiply is limited. The larva will survive for weeks without food and will wander about in search of suitable food if it should find itself, for one cause or another, on that which is unsuitable. It undoubtedly thrives best on Acacias, and next to these we should place the Citrus fruits, the Quince, and the Pomegranate, and we doubt if it could thrive upon many other trees. The list of its food-plants, or rather of plants upon which it has been found, is longer than is justified, not only because of its power of endurance above noted, but because the young are easily carried by wind or otherwise to plants more or less uncongenial and on which they ultimately perish, while the adults are often dislodged from infested Acacia or Citrus trees onto plants under or near them.

Among the more valuable trees upon which it certainly cannot thrive, and upon which it does not occur when they are grown at some distance from infested Acacia or Citrus trees, are the following: Pines, Cypress, Eucalyptus, Olive, Apricot, Peach, Pear, and Oleander.

The plants upon which Mr. Coquillett found females with egg-masses in limited numbers, and which were growing in situations so remote from any infested Acacia or Citrus trees as to preclude the idea that the adult insects had found their way to these plants from such trees, were as follows:
Pomegranate.
Quince.
Apple.
Peach.
Apricot.
Fig.
Walnut.
Locust.
Willow.

Pepper.
Grape.
Rose.
Castor-bean.
Spearmint.
Rose-geranium.

Mr. Koebele, whose observations have been close and extensive, found that the Quince is always thickly infested, as is also the Pomegranate, while on Pear, Apple, Peach, and Apricot the scales were not numerous in the adult state. Only a few scales, and these nearly always small, were found upon the Castor-oil bean. Some Pecan-trees were noticed on which some of the branches were completely covered with scales. A Willow hedge surrounded by plants which had been infested for over two years did not itself become attacked until the past summer. The Fig he states to be a favorite food-plant. On Eucalyptus he found young scales all summer, and in October he found twigs full of scales of all sizes. A few full-grown individuals were found upon a single Pepper tree (*Schinus molle*) growing in the orchard. The following is a supplementary list of plants upon which Mr. Koebele reported the scales most noticeable:

Portulaca oleracea—Scales often numerous.
Malva rotundifolia.
Grape (*Vitis* spp.)—Scales occurring principally on petiole and leaf.
Medicago denticulata.
Helianthus spp.
Rose (*Rosa* spp.)—Scales growing often to an unusually large size, and very numerous on some varieties.
Epilobium coloratum.
Erigeron canadensis.
Bidens pilosa.
Artemisia ludoviciana.
Ambrosia psilostachya—Hundreds of scales on each plant during July, August, and September.
Sonchus oleraceus.
Plantago spp.
Mentha piperita.
Stachys æquata.
Solanum tuberosum.
Solanum douglasii.
Chenopodium murali.
Chenopodium album.
Amarantus retroflexus.
Polygonum persicaria—Stem often entirely covered by scales.
Rumex crispus.
Urtica holosericea—A favorite plant, on which the scales developed with unusual rapidity and to large size.
Carex spp.
Paspalum spp.
Panicum crus-galli.

CHARACTERS AND LIFE HISTORY.

The genus *Icerya* was first described by Signoret in the Annales de la Société Entomologique de France" for 1875, pp. 351, 352, and was founded on the single species *I. sacchari* (Guérin), which occurs on sugar cane at the Island of Bourbon. He knew only two stages, the

full-grown female and the newly hatched larva, but these were described with his customary care.

Mr. Maskell, in describing the species under consideration, places it without much hesitation in this genus, and later, in 1883, still places it in *Icerya*, after examining specimens of *I. sacchari* sent him by M. Signoret. In his original paper (Trans. Proc. N. Z. Inst., 1878, 220), Mr. Maskell describes quite carefully the egg, the young larva, the second stage, and the full-grown female, but had not seen the male larva, cocoon, or adult. Professor Comstock (Ann. Rept. Dept. of Agric., 1880, p. 347) follows Maskell's description quite closely, and introduces no new facts.

There is therefore a necessity for a careful review of the complete life history of the insect, and this we have endeavored to give in the following pages.

THE EGG (Plate II, Fig. 1).—The egg is quite smooth, elongate-ovate in form, and is of a deep orange-yellow color. It measures about 0.7^{mm} in length.

The average number of eggs laid by the female varies according to the vigor of the individual or the condition of the plant upon which she dwells; prolificacy diminishing in proportion as the plant is badly infested—a general law among Coccidæ. Over 800 eggs have been counted in a single egg-mass by Mr. Coquillett, while Mr. Koebele has counted in a single egg-mass, which, by the way, was found upon nettle (*Urtica holosericea*), 940 eggs and 72 young larvæ, while 123 eggs yet remained in the dead body of the female, making a total of 1,135 eggs from the single female.

The time required for the eggs to hatch after leaving the body of the female varies with the temperature. In the winter-time the sacs are usually filled with eggs, while in the hottest part of the summer seldom more than one or two dozen will be found in each sac. Some collected by Mr. Coquillett on the 18th of March did not hatch until the 10th of May; but in mid-summer hatching is only a matter of a few days.

THE FEMALE LARVA—FIRST STAGE (Plate I, Fig. 2, and Plate II, Fig. 2).—The newly hatched female larva (and probably the male is identical with it at this stage of growth, since we have not been able to separate them into males and females) is red in color, inclining somewhat to brown. The body is ovoid in outline, being flattened beneath and convex above. The antennæ are long and 6-jointed. Joint 1 is short and stout, and as broad as long; joints 2, 3, 4, and 5 subcylindrical and subequal, much more slender than joint 1, and twice as long as broad; joint 6 is as long as 4 and 5 together, and forms a long club, at base equaling joint 5 in diameter, but broadening out to twice its width at tip. The basal portion of the club is sometimes distinctly separate from the rest, forming an additional joint. All joints have a few sparse hairs, and the club, in addition to several short ones, bears near its tip four very long ones, each of which is considerably longer than the whole antenna. The legs are thin and brown in color. The coxæ and femora are moderately large, while the tibiæ and tarsi are long and thin, the terminal joints of the latter bearing several long hairs. The upper digitules are represented by simple hairs, but the lower ones are present and are bent near the base. The eyes are prominent and are each mounted on a short tubercle. The mentum is broad and apparently 2-jointed. The rostrum is broad at base and the rostral setæ are not very long. At the tip of the rounded abdomen are 6 small tubercles, 3 each side of tip, each of which carries a

long stout hair, which is as long as the whole body. The body above shows 6 rows of secretory pores, 4 along the middle, and 1 on each side. More or less regular rows of hairs alternate with these pores.

FEMALE LARVA—SECOND STAGE.—According to Maskell and Comstock, there are but three stages of growth in the female after hatching, and these are readily distinguished by the number of antennal joints; the larva of the first stage having 6, that of the second 9, and the adult 11. Messrs. Coquillett and Koebele came to the same conclusions, and all have overlooked a form which we have found quite abundantly among the material we have studied, and which seems to constitute an intermediate stage between the so-called first and second, and which is of course produced by an additional molt which we have personally observed in the field. Hence the so-called "second stage" of these authors becomes third, while the adult female is fourth instead of third, and there are 3 molts instead of 2.

This new intermediate form (Plate II, Fig. 3) differs from the female larva of the first stage in the following respects: It is much more rounded and of a stouter general appearance. The antennæ have the same number of joints, 6, but their relative proportions are quite different. The antennæ as a whole are relatively much shorter. Joint 1 is short and stout, its length equalling its breadth; joint 2 equals joint 1 in length, but is not quite so broad; joint 3 is as broad as joint 2, but is twice as long; joints 4 and 5 are equal in length and width, each narrowing somewhat at base and tip, each considerably narrower than joint 3, and each of the same length as joint 2; joint 6 (club) is of an irregular shape; at base it is as narrow as joint 5, but it broadens until it is slightly wider than 2 or 3, and its tip is narrowed again; its shape is that of an irregular rhomboid with rounded angles and sides, the acutest angles at base and tip. The antennæ carry about the same number of hairs as in the first stage, but those homologous with the four very long hairs of the club in that stage are in this second stage but little longer than the other antennal hairs. The eyes do not appear on the margin of the body, and are only seen on a ventral view. The legs are proportionately much shorter, and the femora are stouter; the trochanters are broader distally, and consequently form a broader triangle in shape. The six tubercles at the anal end of the body are still present, but the hairs which they bear are much shorter. The secretory pores are no longer arranged in rows, but are scattered sparsely over the back and under the sides. The back is more hairy, and the short black hairs occur in irregular tufts.

FEMALE LARVA—THIRD STAGE (Plate II, Fig. 4).—That which has heretofore been considered the second stage, and which, as we have just seen, is the third, may be described as follows:

The body is broadly oval in shape and reddish-brown in color, but is soon obscured more or less by the thick, curly, cotton-like excretion. The antennæ are 9-jointed instead of 6, and are subcylindrical, tapering somewhat from base to tip. Joints 4, 5, 6, 7, and 8 are subequal in length, and each is about as long as broad; joints 2 and 3 are broader and considerably longer; joint 1 is like the corresponding joint in the previous stage; joint 9 (club) is a suboval joint, proportionately much smaller than in the previous stages; it does not exceed joint 8 in width, and it does not quite equal joints 7 and 8 together in length. The long hairs of the club are proportionately quite short. The insect as a whole is much more hairy than in either of the previous stages. The hairs are short and black, and show a marked tendency

to grow together in tufts; even when their bases are well separated their tips turn toward each other or toward the common center of a group; they are quite thickly scattered over the thorax, but less so over the abdomen; all around the edge of the body they appear in close tufts, and the concentric subdorsal ring of tufts which is so prominent in the next stage is plainly seen in this. The secretory pores are scattered irregularly all over the back, and are more numerous than in the previous stage; they also occur under the lateral edges of the body. They are small and circular, and, seen directly from above, have a double outline, indicating a circular central orifice. Around the edge of the body is a row of much larger pores, brown in color, which protrude from the body, masked by the lateral tufts of hairs, each with a circular crown or lip at tip, from which proceeds a long, fragile, glassy tube. (Plate II, Fig. 6.) The legs and feet are a little stouter than before, the tarsal digitules are shorter, and their enlarged tips quite indistinct. The six anal hairs are still present, though hardly noticeable as they protrude from the mass of shorter hairs.

THE ADULT FEMALE—FOURTH STAGE (Plate II, Fig. 5).—Immediately after the molt by which the insect passes into this stage, it is free from the waxy excretion and presents a broadly oval form, flattened below and quite strongly convex above, with two prominent raised surfaces on the second and third thoracic segments. Its color is still reddish brown, with several darker spots, especially upon the front half and along the sides of the posterior half of the body, and the antennæ and legs are black. The antennæ are now 11-jointed instead of 9; joint 1 is nearly twice as wide as long; joints 2 and 3 are subequal in length and thickness and are each somewhat longer than broad; joint 4 is a little more than half as long as 3 and is narrower; joints 5, 6, 7, 8, 9, and 10 increase gradually and slightly in length and decrease very slightly in width; joint 11 (club) is irregularly ovoid and is one and one-half times as long as 10; the special hairs are a little shorter than in the previous stage. The whole body is furnished with short, black hairs, more numerous than in the last stage, arranged in tufts, particularly around the edge, where they occur in a double parallel row, the inner row being practically subdorsal and accentuated by a slight ridge. Down the central portion of the dorsum of the abdomen the segments are indicated by the transverse rows of hair tufts. The secretory pores are exceedingly abundant, occurring in enormous numbers just under the lateral edges of the body, and scattered more sparsely over the back. The individual wax filaments which issue from these pores are very delicate and curly, and there is reason to suppose that two or three issue at one time from one pore, as they are frequently seen connected at base; the pore opening, however, seems to have a single simple opening. The inner row of tufts on the back is broken at its anal point by a depression, in which is situated a very large pore, from which the insect occasionally ejects a globule of a semi-liquid honey-dew. This depression is surrounded by an irregular ring of hairs, which are yellowish in color instead of black. The glassy filaments arising from the large tubular pores described in the last stage are now very long and radiate from the body in almost every direction. They break off easily, yet still often reach a length double that of the insect and her egg-sack together. What is probably the opening of the oviduct is situated on the under side of the seventh abdominal segment. It is surrounded by a transversely oval chitinous ring.

THE EGG-SAC (Plate I, Fig. 4).—As the body of the female begins to swell from the eggs forming inside, the beginning of the egg-sac is made. The female lies flat on the bark, the edges of the body turned slightly upwards, and the waxy material of which the sac is composed begins to issue from countless pores on the under side of the body, but more especially along the sides below. As the secretion advances the body is raised, the cephalic end being still attached, until, near the completion of the sac, the insect is apparently standing on its head, nearly at right angles to the surface to which it is attached. The egg-laying commences as soon as a thin layer of the secretion has formed on the under side of the abdomen, and it continues during the formation of the sac. There soon appears around the edge of the abdomen a narrow ring of white feltlike wax, which is divided into a number of flutings (Plate I, Fig. 3). These flutings grow in length and the mass of eggs and wax under them increases, forcing the female upward until the sac is completed. When completed, it is from two to two and one-half times the length of the female's body. It is of a snow-white color, and the outside is covered with 15 of these longitudinal ridges or flutings, of subequal size, except that the middle one is smaller than the others. The upper part of the sac is firm in texture, but the lower is looser and thinner, and from the middle of the under side the young make their escape soon after hatching. The size of the sac and the length of time required in its growth depends, leaving the weather and the health of the food-plant out of consideration, upon the number of eggs which the female deposits. So long as oviposition continues, the secretion of wax accompanies it and the egg-mass grows. Concerning the rate of growth Mr. Coquillet gives the following instance:

"On the 4th of May of the present season I marked a large number of females which were located upon the trunk of an orange tree that was not in a very healthy condition. These females had just begun to secrete the cottony matter, the latter at this date being in the form of short but broad tufts around the margin of the abdomen, those at the hind end of the latter being longest. By the 31st of May the cottony matter was equal in length to one-third of the female's body, and by the middle of July it about equaled in length the entire body of the female. As the egg-masses of some of the females upon the same tree were longer by one-half than the bodies of the females which produced them, it is very probable that at least another month must elapse before the egg-masses of the females which I observed would be completed. It is altogether likely, however, that these egg-masses would have been completed in a shorter time had the females been located upon a healthy tree. The egg-masses found upon healthy trees attain larger size than those found upon sickly trees, owing doubtless to the fact that the females living upon trees of the former kind are more vigorous than those upon unhealthy trees."

THE MALE LARVA—PROBABLE SECOND STAGE.—Neither Mr. Coquillett nor Mr. Koebele were able to distinguish the male larvæ until these had reached the stage in which they form their cocoons. Among the specimens studied at the Department, and which were sent alive from Los Angeles by Mr. Koebele, we have found a larval form which has not yet been described, and which we strongly suspect may be the male in the second stage. This form is illustrated at Fig. 7, Plate II. It differs from our supposed second stage of the female in its more slender form, longer and stouter legs, and longer and stouter antennæ. The legs and antennæ are not only relatively

longer and stouter, but are absolutely so. The body above is much more thickly clothed with the short stout hairs than the corresponding female stage, and the mentum is longer and darker colored. The antennæ are 6-jointed, and the joints have precisely the same strange relative proportions as in the female. The secretory pores are present, but are not quite so numerous as in the female.

MALE LARVA—THIRD STAGE.—In this, the third or last larval stage, the male is readily distinguished with the naked eye from the female in any stage by the narrower, more elongate, more flattened, and evenly convex form of his body, as well as by his greater activity in crawling about the trunk or branches of a tree. More careful examination shows that the beak is entirely wanting, the tubercle from which it arises in the earlier stages being replaced by a shallow triangular depression. The body is almost naked, being very sparsely covered with a short, white, cottony matter, and is destitute of the short but stout black hairs which are found upon the body of the female during the third and fourth stages of her life. In the absence of black spots and in the 9-jointed antennæ he agrees with the similar or third stage of the female, and the average length when full grown is about 3^{mm} and diameter about 1^{mm}.

THE MALE PUPA AND COCOON.—When the male larva has reached full growth and is ready to transform it wanders about in search of a place of concealment, finally secreting itself under a bit of projecting bark, under some leaves in the crotch of the tree, or even wedging itself down under a mass of females. Very frequently, probably in the majority of cases, it descends to the ground, and hides under a clod of earth or works its way into some crack in the ground. Having concealed itself, it becomes quiescent, and the delicate, flossy substance of which the cocoon is formed begins to exude abundantly from the body. This material is waxy in its character, but is lighter and more flossy and less adhesive than that of which the egg-sac of the female is composed. After a certain amount has been exuded the larva moves backwards very slowly, the exudation continuing until the mass is from 7^{mm} to 10^{mm} in length. From this method of retrogression it happens that the body of the larva is frequently seen protruding posteriorly from the mass, which naturally leads to the erroneous conclusion that the material is secreted more abundantly from the fore part of the body, whereas the reverse is the case. When the mass has reached the proper length the larva casts its skin, which remains in the hind end of the cocoon, and pushes itself forward into the middle of the cocoon.

The pupa (Plate II, Fig. 8) has the same general color as the larva, the antennæ, legs, and wing-pads being paler and the eyes dark. It has also the same general form and size. All the members are free and slightly movable, so that they vary in position, though ordinarily the antennæ are pressed close to the side, reaching to basal part of metathorax (ventrally); the wing-pads also against the side, elongate-ovate in form and reaching to second abdominal joint. The legs are rather shorter than the diameter of body, and the front pair thrust forward. The anal end is deeply excavated, the abdominal joints well separated, the mesonotum well developed, and the pronotum tuberculous or with some 8 prominences; but there are no other structural peculiarities. The surface is, however, more or less thickly covered with waxy filaments, which are sometimes exuded in sufficient quantities to give quite a mealy appearance.

Whenever the pupæ are taken from the cocoon and placed naked

in a tin box they exude a certain amount of wax, often enough to partially hide them from view. If disturbed, they twist and bend their bodies quite vigorously.

The cocoon (Plate I, Fig. 5) is of an irregular elongate shape, appearing a little denser in the center, where the pupa has placed itself, and at the edges delicate and translucent. The material of which the cocoon is composed is very delicate, and appears like the finest cotton, but on submission to a gentle heat it melts as readily as the coarser secretion of the female, and leaves the larva or pupa, as the case may be, clean and exposed.

THE ADULT MALE (Plate I, Fig. 1).—A careful description of the male of this species has never been published. It was unknown to Mr. Maskell at the date of his first paper and has not been mentioned in any of his subsequent papers. Mr. Trimen attempted to breed it, but was unsuccessful. He says: "So little is certainly known of the males of the Coccidæ that I have kept from time to time a large number of this Dorthesia under glass in the hope of obtaining the males, but hitherto without success. I once, however, found on my window a male of some Coccus which I thought was very probably that of the introduced species, as it agreed in most of its important characters with Westwood's figure of the male *Dorthesia characias*. It was dark-red, with the wings gray, and very slender and fragile in its structure. It measured $\frac{15}{48}$ inch across the expanded wings."

The male was unknown to Professor Comstock, but was very briefly mentioned by Dr. Chapin in the first report of the Board of State Horticultural Commissioners, Sacramento, 1882, p. 68. He found the male in numbers during a period of two weeks from September 25, 1881, but did not observe it in 1882. It is also mentioned by Matthew Cooke in his "Injurious Insects," &c., 1883, p. 166, and a rough and uncharacteristic figure is given at Fig. 146, Plate 3. His few words of description are: "Male insect, winged; color, thorax and body dark brown; abdomen, red; antennæ, dark colored, with light hairs extending from each joint; wings, brown, iridescent." The following detailed description is drawn up from numerous specimens, both mounted and living:

The adult male is a trifle over 3^{mm} in length, and has an average wing expanse of 7.5^{mm}. The general color is orange-red. The head above is triangular in shape, with the apex blunt and projecting forward between the bases of the antennæ. The eyes are placed at the other apices of the triangle, and are large, prominent, and furnished with well-marked facets. There are no mouth-parts, but on the under side of the head is a stellate black spot with five prongs, one projecting forward on the conical lengthening of the head, one on each side to a point just anterior to the eyes and just posterior to the bases of the antennæ, and the remaining two extending laterally backwards behind the eyes. The antennæ are light brown in color and are composed of ten joints. Joint 1 is stout, almost globular, and nearly as broad as long; joint 2 is half as broad as 1 and is somewhat longer; joint 3 is nearly twice as long as 1 and slightly narrower than 2; joints 4, 5, 6, 7, 8, 9, and 10 are all of about the same length as joint 3, and grow successively a little more slender; each joint, except joint 1, is furnished with two whorls of long light-brown hairs, one near base and the other near tip; each joint is somewhat constricted between its two whorls, joint 2 less so than the others. There are no visible ocelli. The pronotum has two wavy subdorsal longitudinal black lines, and the mesonotum is nearly all black, except an oval patch on the scutum. The metanotal spiracles are black, and there is a transverse crescent-shaped black mark, with a short median backward prolongation. The mesosternum is black. The legs are also nearly black and quite thickly furnished with short hairs. The wings are smoky black, and are covered with rounded wavy elevations, making a reticulate surface, a cross-section of which would appear crenulate. The costa is thick and brown above the subcostal vein, which reaches costa at a trifle more than four-fifths the length of the wing. The only other vein (the median) is given off at about one-sixth the length of the wing, and extends out into the disk a little more than one-half the wing length. There are,

in addition, two white lines, one extending out from the fork of the subcostal and the median nearly straight to the tip of the wing, and one from the base in a gradual curve to a point some distance below the tip. Near the base of the wing below is a small ear-shaped prolongation, folded slightly on itself, making a sort of pocket. The halteres are foliate, and furnished at tip with two hooks, which fit into the folded projection at base of wings. The abdomen is slightly hairy, with the joints well marked, and is furnished at tip with two strong projections, each of which bears at tip four long hairs and a few shorter ones. When the insect is at rest the wings lie flat upon the back.

RATE OF GROWTH OF THE DIFFERENT STAGES.

The rate of growth of the insect necessarily depends so much upon surrounding conditions, and especially on the mean temperature, that it is difficult to make any definite statements as to time elapsing between molts or that required for other periods of the insect's growth. No facts have hitherto been published which bear upon this point. Mr. Coquillett's observations show that individuals hatched from eggs on the 4th of March cast the first skin on the 23d of April, and underwent the last molt on the 23d of May. Mr. Koebele also reports a case which bears upon this point, and which is interesting as occurring later in the season. He placed four newly hatched larvæ on a healthy young orange tree, out of doors, August 5. On September 26 two of them passed through the first molt. October 10 one more molted, and on October 23 the fourth cast its first skin. All left the leaves after molting and settled on young twigs. None of them had gone through the last molt when he left Los Angeles, November 6. He was afterwards informed by Mr. Alexander Craw, of Los Angeles, that nearly all of the insects were full-grown in February, and he therefore concluded that the individuals observed by him would not attain full growth before that time.

The mature male larva requires on an average about ten days from the time it begins to form the cocoon before assuming the pupa state, and the pupa state lasts from two to three weeks. The more reliable information we have been able to obtain, would show that at Los Angeles the average number of generations each year is three.

HABITS.

The newly hatched larvæ settle upon the leaves and tender twigs, insert their beaks, and imbibe the sap. On passing into the third stage they seem to prefer to settle upon the smaller twigs, although a few are found upon the leaves and still fewer upon the larger branches and trunk. The adults, however, almost invariably prefer the trunk and largest branches.

The insect is rarely found in any of its stages upon the fruit.

The species differs markedly from most Coccidæ in being active during the greater part of its life, though most of the traveling is done by the female immediately after the third molt and by the male just before settling to make his cocoon. At these periods they wander up and down the trunk and larger limbs until they find some suitable place, when they settle down, the male to pupate and the female to insert her beak and develop her eggs and their characteristic waxy covering. She is capable of slow motion even after oviposition has commenced, but rarely does move unless from some exceptional cause. In thus settling after their last wanderings both sexes are fond of shelter and will get under any projecting piece of

bark or under bandages placed around the tree, the male often creeping under clods of earth. Both the female and the male, in adolescence, are most active during the hotter parts of the day and remain stationary at night; but the perfect or winged male is rather sluggish during the day, usually remaining motionless on the under side of the leaves of low plants or high trees, in crevices of the bark, or wedged in between females on the tree. There seems, in fact, to be a well-marked attempt at concealment. The recently developed individuals are found abundantly on or under clods of earth near their pupal cocoons, and they issue most numerously during the latter part of the afternoon. They are at first weak, awkward, and ungainly, and instinctively seek some projection on the tree or elevation on the ground from which to launch on the wing.

At the approach of night they become imbued with a very high degree of activity and dart rapidly about on the wing. At such times they swarm around the infested trees, and many of the females, even some with large egg-masses, hold their bodies raised obliquely from the bark, as though aware of the presence of the males. In September and October Mr. Koebele noticed that the males began their flight about 5 o'clock, and as soon as it was fairly dark they again settled down to rest. None have been observed flying at night and none have been attracted to the electric lights.

EXUDATION OF THE HONEY-DEW.

It required but a few hours upon our first visit to Los Angeles, the latter part of March, to become familiar with the insect in all its habits and conditions, as at that season the species is to be found in all conditions from the egg through all the stages of both sexes. But the characteristic of this remarkable insect which most obviously attracted our attention and distinguished it from all other species of the family, even where there were no gravid females with the fluted cushion, was the saccharine exudation. As with most Aphids and Coccids, this sweet liquid is exuded at all stages of growth, but is most copious from the adult female just before oviposition begins. It is expelled with considerable force from the large pore already described, and in hot weather with sufficient rapidity to produce all the effects of honey-dew. Usually it is limpid enough to soak and discolor the trunk and to drop as it accumulates from the leaves, sometimes being so copious as to remind one of a shower; but at other times, and especially during dry weather, the sugar condenses and forms large drops or masses of white, semi-opaque, sirupy liquid, which adheres to and often completely covers the insect, so that the trunk of the tree looks much as if it had been bespattered with caustic potash or melted stearine. At other times the liquid parts evaporate entirely and leave masses of pure white powdery sugar.

Honey-loving insects seek this sugary secretion in numbers, and it is always followed by the black mold or smut (*Capnodium citri*), which is so universal an accompaniment of all honey-secreting Homoptera, living as it does on the saccharine deposit. The secretion being so very copious from Icerya, the smut is equally thick and copious in her wake. Indeed, the great prevalence of this smut in the Icerya-infested groves of California (rendering it necessary to wash or cleanse the gathered fruit) is as characteristic of the Pacific coast as the rusty effect of the Rust-mite (which is unknown there) is of the orange groves of Florida.

MODE OF SPREAD AND DISTRIBUTION.

The spread of this species will be aided by very much the same agencies that affect the spread and dissemination of other species of scale-insects. We have already, in 1868, in treating of the Oyster-shell Bark-louse of the Apple,* and again four years later,† discussed the principal methods by which such spread is promoted, viz, by the agency of wind and running water; by the young being carried upon birds and other animals, particularly flying insects frequenting the same trees; but primarily by transport upon scions and nursery stock.

In insects like the Coccidæ, where the locomotive power is confined for the most part to a few days in early larval life, the species would be very much restricted in range, and would never pass from one country to another, except by some of the agencies above indicated. Our observations since we first wrote upon this subject, as well as the extended observations of Mr. Hubbard in Florida, and given in the special report on Insects affecting the Orange, as also Mr. Coquillett's observations on the distribution of the particular species in question, all go to confirm the potency of these means of distribution. Thus Mr. Hubbard found that lady-birds (Coccinellidæ), and more particularly gossamer spiders, are active agencies in such distribution. The agency of the wind, as indicated by the more rapid spreading in the direction of prevailing winds, has often been verified. Mr. Coquillett reports: "In the infested part of this city (Los Angeles) is a large vineyard, and on both the north and south sides of it is an orange orchard infested by these insects; but, while the recently hatched insects occur on the vines as far out as the tenth row of grape-vines on the south side of the vineyard, they are not found upon the vines beyond the third row on the north side, the wind, as stated above, blowing from the southwest. No adult females are to be found on any part of this vineyard, and the young insects must have been carried by the wind from the infested orange trees on either side of the vineyard." Our own experience in California showed that similar evidence of the influence of the prevailing wind in promoting the spread of the species is general.

While Mr. Hubbard's observations show that the action of the wind is indirect rather than direct, by influencing the flight of winged insects and the floating of spiders which transport the scale-insects, yet we have every reason to believe that winds have a much more direct influence than is generally supposed, especially in the case of severe storms passing over infested districts at the right season. We laid emphasis on this in our earlier writings, and Mr. Coquillett, while admitting the influence of birds, insects, and water in the transportation of our *Icerya*, lays greatest stress upon the direct agency of the wind. Young scale-insects are not easily dislodged, but where a tree is badly infested there is every reason to believe that they instinctively drop from the terminal twigs, and their specific gravity is so slight, that they may be carried long distances in strong wind currents.

In regard to the influence of birds upon the spread of the Cottony Cushion-scale, Mr. Coquillett observed that whenever the nest of a bird is found upon a tree recently infested with this insect, the latter will be found to be most numerous in the immediate vicinity of the

* First Report Insects of Missouri, p. 15.
† Fifth Report Insects of Missouri, pp. 85, 86.

nest, thus indicating that the young had been accidentally brought there and in considerable numbers by the old birds. There is no doubt also that the irrigating ditches have a very marked influence on the spread of the species, as many of the ditches pass under infested trees, and the waxy secretion serves both to protect the insect from the water and to facilitate floating.

While, therefore, the gradual spread from orchard to orchard is in the main through the agency of other flying insects and gossamer spiders, yet the transportation of the pests to long distances must necessarily be effected through the agency of high winds, birds, and man in commercial intercourse, the latter being probably the only means by which the species have been introduced from one country to another separated by wide ocean areas.

NATURAL ENEMIES.

BIRDS.—The natural enemies of the Cottony Cushion-scale seem to be very few in number, not only in California but also in South Africa and New Zealand. In South Africa the only bird which is recorded as feeding upon this scale is the common "White Eye" (*Zosterops capensis*), and this is given by Mr. Trimen upon hearsay evidence only: "I have not noticed any of our small birds attacking the *Dorthesia*, but Mr. C. B. Elliott tells me that his boys have observed the little 'White Eye' * * * pecking at them." From what we have been able to learn of the habits of this bird, however, we are inclined to think that it is attracted rather by the abundant secretion of honey-dew and the minute insects caught in it than by the scale-insects themselves.

Neither Mr. Coquillett nor Mr. Koebele observed any bird feeding upon it. The reason for this exemption is probably the copious secretion of wax, which is doubtless distasteful. Several reliable persons report that ducks and chickens feed greedily upon those scale-insects which are dislodged from the trees. On one occasion a brood of six young ducks gorged themselves upon scales which had been washed from the trees with pure water, and on the same day two ducks died. On the day following three more died, while the sixth recovered after an illness of several days. This disastrous effect was probably due to the greed with which the scales were eaten, as they were said to produce no such result with chickens which ate them at the same time.

PREDACEOUS INSECTS.—The only predaceous insect observed by Mr. Coquillett to feed upon the Cottony Cushion-scale was the larva of a species of Lace-wing fly (*Chrysopa* sp.), which was not bred and cannot be named more exactly.

The Ambiguous Lady-bird (*Hippodamia ambigua*) has been noticed feeding upon the eggs when they were exposed to view by the egg-sac being broken open; but neither this nor any other species of Lady-bird was seen to feed upon the adult insect, although commonly attracted by the honey-dew secreted.

Among the predaceous insects found by Mr. Koebele and sent to us for study we may mention first the larva of a small moth (*Blastobasis iceryæella* n. sp., Plate III, Fig. 3), although as yet we are not certain that it ordinarily preys upon the living and uninjured scale-insects or their eggs. Like certain other so-called predaceous Lepidoptera, it may be attracted primarily by the waxy secretions of the bark-lice, and only incidentally destroy the insects and their eggs.

These larvæ were often found feeding in the egg-masses of females which had been destroyed by soap washes, and also in sacs the eggs of which had hatched some time previously, but never upon fresh eggs. One of the larvæ, kept in a glass tube with living scales and fresh eggs, fed slightly on the waxy mass, but did not thrive until after the scales died. It then fed upon the dead scales and molted, but died before transforming. Two nearly full-grown larvæ fed readily on dead scales which were still soft, and passed through their transformations successfully. The same insect fed readily upon the Black Scale (*Lecanium oleæ*), in this case eating the living insects and their eggs, forming a silken tube along the twig, and passing from one scale to another, just as does the Coccid-eating Dakruma (*Dakruma coccidivora*)* in feeding upon the Cottony Maple Scale at the East.

This is probably the same insect as that mentioned by Professor Comstock, Annual Report Department of Agriculture, 1880, p. 336, as follows: "Upon one occasion (August 25, 1880), I found within the body of a full-grown female [of *L. oleæ*] a lepidopterous larva. * * * The specimen, however, was lost, and no more have been found since." From the fact that this larva destroys living Black Scales, we have every reason to believe that it will also feed upon living Cottony Cushion-scales, and will not confine itself, as heretofore observed, to the dead females and their empty egg-sacs.

Blastobasis aphidiella, Riley MS., we have reared from the larvæ feeding on the contents of Phylloxera hickory galls.

The genus *Blastobasis* Zeller is distinguished by the first antennal joint being compressed and much broader than the flagellum; its lower side concave, the anterior edge above its base furnished with erect hairs; its apex above provided in the male with a scaly tooth; the flagellum in the male is filiform, faintly serrate, and furnished with short ciliæ, its base curved and anteriorly excised; in the female it is simple. The palpi are as long as thorax and rather stout in the male, faintly compressed and covered with coarse scales, the last joint slightly over half the length of the middle one and its apex pointed. The ocelli are present. The front wings are narrow, their apical portion quite slender and pointed; eleven-veined, vein 1 *b* distinct. The hind wings have seven well-separated veins. This is not the place to discuss the variation which the species of the genus are subject to; but they are small in size, quite uniform in general color and markings, but varying so in the intensity and the details of ornamentation that the species are not easily separated, and we shall not be at all surprised if future experience should justify the combining of several which are now separated.

BLASTOBASIS ICERYÆELLA n. sp.—Expanse 13^{mm} to 15^{mm}. General color pale cinereous. *Head* gray; eyes dull black, fringed posteriorly by rather long yellowish hairs, which curve over them like eyelashes; palpi above pale yellowish-gray; in some specimens the inferior surface is almost black, whilst in others there is only a slight sprinkling of blackish scales; antennæ uniformly gray, with a slight yellowish tinge and faintly darker annulation, the tuft of the basal joint almost white. *Primaries* cinereous, sprinkled quite densely with blackish scales; a linear, blackish, transverse band more or less distinct (in one male only indicated by a small dusky spot at costa), starting from basal third of costa and obliquing posteriorly, it terminates at about the middle of inner margin; its inner edge is bordered by a more or less distinct paler gray line; the black discal spot, which in other species is usually

* We have bred a species of *Dakruma* the past season, indistinguishable from *D. coccidivora*, from the Cochineal insect (*Coccus cacti*) received from Dr. A. F. Carrothers, of San Antonio, Tex., who collected the specimens at his ranch (Iuka ranch) near Cotulla, La Salle County, Texas.

external of the band, in this species forms part of the band; the two black spots on a transverse line with anal angle are always present, though the posterior one is sometimes more or less obliterated; these spots are generally relieved posteriorly by a patch of paler scales, while posteriorly and exteriorly of this pale patch the black scales are sometimes increased so as to resemble a transverse posterior band with a pale interruption. Under surface uniformly gray, with slight brassy reflection. Secondaries pale gray above, glossy below, with brassy reflection. Fringes of all wings still paler, with a yellowish, silky luster. Legs pale gray, the anterior or external surface of the front and middle legs, including coxæ, being in some specimens dark gray or almost black, while in others there is only a slight sprinkling of darker scales. In one specimen there is noticed a quite dark band near the apex of the middle tibiæ; hind legs whitish, sometimes with a faintly dusky, longitudinal streak externally on the tibiæ; abdomen of a lighter or darker silvery gray, generally somewhat darker towards the end, the anal tuft of the male more or less yellowish.

Described from four ♂s and one ♀ reared from Icerya-feeding larvæ.

We have not seen good specimens of this larva, and may therefore quote Mr. Koebele's brief description, drawn up from fresh specimens:

The larva while young is of a reddish-white color, with a narrow, deeper red dorsal line. The piliferous warts are prominent, whitish, with rather stiff white hairs. The head and prothoracic shield are light yellow (testaceous), and bear also a few hairs. The full-grown larva is from 5^{mm} to 6^{mm} long and brownish in color. The narrow, whitish dorsal line is bordered with a mottled liver-brown, and the whitish line beneath this again with a heavier brown subdorsal line. The under side and the feet are still reddish-white, while the head and prothoracic shield are pitch black.

This species is closely related to *Blastobasis chalcofrontella*, and also somewhat to *Blastobasis quisquiliella*, from both of which, however, it may at once be distinguished by the blackish band of the front wings, which in them is wanting or only indicated by a small dusky shade at the costa. The head of *B. chalcofrontella* is also broader and of a yellowish-white color, and the palpi and legs more concolorous with the body, and the general tint of the wings more yellowish.

In *B. quisquiliella* the head, palpi, and legs are more rufous and the general aspect more like *B. chalcofrontella*.

With *B. nubiliella* and *glandulella* it cannot be confounded, as both are generally larger and darker, though some specimens of *nubiliella* are larger than the smaller specimens of *iceryæella*. The band on primaries of *nubiliella* instead of being linear broadens towards the costa so as to form a transversely elongate, triangular spot, which in some particularly well-marked specimens is quite conspicuous.

In *B. glandulella* the band is not indicated or but faintly indicated, and it is at once distinguished by the much larger size and uniformly darker coloration.

A common Tenebrionid beetle (*Blapstinus brevicollis* Lec., Plate III, Fig. 2) was found by Mr. Koebele to occur abundantly among the rubbish at the foot of the trees infested by Icerya. Egg-sacs which had been completely eaten out and the eggs devoured were found in close conjunction with several of these beetles, and in consequence a few beetles were placed in a pill-box with female scales and large egg-masses. In a few days the eggs were all eaten, but the insects themselves were not disturbed. It is probable that this is not the normal habit of this beetle, yet it may without much question be put down as an occasional destroyer of Icerya eggs. The habits of the allied *Epitragus tomentosus*, as described by Mr. Hubbard in his report on Insects Affecting the Orange, p. 75 (Fig. 36), render this all the more probable. The *Epitragus* was observed to feed upon

scale-insects of all kinds in Florida, tearing the scale from the bark and devouring its contents, and sometimes also the substance of the scale itself.

The larva of a Dermestid beetle (*Perimegatoma cylindricum* Kirby, var. *angulare*) was also found among the Cottony Cushion-scales, but as it would only feed on dead scales in confinement, it is not likely that it is truly predaceous.

Prominent among the true bugs found upon the infested trees is the large brown *Largus succinctus* (Plate III, Fig. 4). This is said to destroy the scale-insects, although Mr. Koebele could never see it do so. He noticed it feeding upon the honey-dew, and on one occasion noticed two immature specimens with their beaks inserted in a male larva of Icerya. They ran away on his approach, and the larva was found to be dead; but, as there were numbers of other dead larvæ about, he did not consider that there was any evidence of the predaceous habits of the *Largus*. On the contrary, he observed this insect often with its beak inserted into young shoots of Orange. The other Heteroptera found by him among the scales were the well-known *Piesma cinerea* Say, *Corizus hyalinus* Fabr (Plate III, Fig. 5), *Peritrechus luniger* Say, *Beosus* sp., *Lyctocoris* sp., and *Piezostethus* sp. These last five species have been kindly examined by Mr. Uhler, our best authority in the suborder, and he reports the undetermined species as probably new.

The most efficient destroyer of the Cottony Cushion-scale at Los Angeles is perhaps a species of earwig, family Forficulidæ (Plate III, Fig. 6), neither the genus nor species of which we are able to determine, from the fact that we have only seen immature specimens. According to Mr. Koebele this insect is often met with among the scales, and, from observations which he made, feeds greedily upon the Icerya in all stages, tearing open the egg-masses and eating the eggs, and also tearing and eating the mature insects as well as the larvæ. The breeding habits of the mother earwig and her care of her flock of young have been observed by Mr. Koebele, but have been so well studied by European authors as to need no detail here.

Mr. Koebele also reports the occurrence in the scale masses, in large numbers, of a minute whitish mite, which becomes of a reddish color when full fed, and which he thinks destroys the female scales. We have not seen specimens of this mite, and are therefore unable to determine it.

In a recent communication from Miss Ormerod, already mentioned on p. 467, she writes as follows of a predaceous insect discovered by her correspondent, Mr. Bairstow, of Port Elizabeth, Cape Colony:

It will perhaps be of some interest to mention that Mr. Bairstow has found a species of Coccinella which has proved (as far as our coleopterists are aware) to be previously undescribed, to be so exceedingly serviceable in destroying the "Australian bug," as they call it, that he has been supplying it to applicants. Dr. Baly examined the specimens sent over for me, and I propose to notice it, with full technical description and a figure, as *Rodolia iceryæ*.

PARASITES.—It is a somewhat remarkable fact that no true parasites were ever bred from the Cottony Cushion-scale until the past summer, and still more remarkable that in the course of their careful investigations, extending over a space of six months, neither Mr. Coquillett nor Mr. Koebele succeeded in finding a single parasite upon this insect. From a number of scales, however, sent to Washington by Mr. Koebele November 10, we bred, on December 8, two specimens of a small Chalcid, which is, without question, a true parasite of

Icerya, as the female scales from which they escaped were found each with a small round hole in its back.

This little parasite (Plate III, Fig. 1) is prettily marked with black and yellow. It is new to our fauna and may have been imported with its host. We turned it over to Mr. Howard for study, and as he finds it necessary to erect a new genus for it, we append his generic and specific characterizations:

ISODROMUS n. g., Howard.

Female.—The antennæ arise near the border of the mouth; the scape is not widened; *the pedicel is much longer than the first funicle joint;* the funicle joints increase slightly in length from 1 to 6 and considerably in width, so that joint 6 is more than twice as wide as joint 1; the club is half as long as the funicle and is obliquely truncate from base to tip. The head is thin antero-posteriorly; the facial impression is slight; *the inner borders of the eyes are nearly parallel*; the ocelli are placed at the corners of a right-angled triangle. The scapulæ meet on a long line at middle. The hind femora have a very delicate longitudinal furrow below. The marginal vein of the fore wings is entirely wanting; the stigmal is moderately long and *bends abruptly downward, forming at first a right angle with the submarginal,* afterwards curving slightly outwards; *the postmarginal is absent. The large mesopleura are covered with a number of longitudinal ridges.*

Male unknown.

This genus belongs to the *Encyrtinæ,* and is more closely related to *Homalotylus* than to any other described genus. Its structural affinity to this genus is quite marked, but it is well separated by the characters italicized above. It differs in habit also, as *Homalotylus* is parasitic upon coleopterous larvæ of the families Coccinellidæ and Chrysomelidæ.

ISODROMUS ICERYÆ, n. sp., Howard.

Female.—Length 2.2^{mm}; expanse 4.2^{mm}; greatest width of fore wing 0.7^{mm}. Head and thorax nearly smooth; head very delicately punctured and furnished with a very few larger impressions. Pronotum and mesonotum very delicately shagreened; mesoscutum and hind border of pronotum with a number of closely applied white hairs. The general color is shining black; all of the head except eyes and an occipital black blotch, the hind border of both pronotum and mesoscutum, all of the tegulæ except tip, a blotch each side of the mesoscutellum and one at tip, the under side of thorax and base of the abdomen, the upper side of the first abdominal joint, and a small spot at the abdominal spiracles, yellow. The yellow of the head is nearly orange, while the rest is more of a lemon. The antennæ are honey-yellow throughout, becoming dusky towards tip. All the legs, including coxæ, are yellow; hind femora dark above, black at knees; hind tibiæ with two black bands. Wings clear. Described from 2 specimens.

REMEDIES AND PREVENTIVE MEASURES.

We have indicated in the introduction to this report the more important results of the experiments carried on at Los Angeles by Messrs. Coquillett and Koebele, and as their reports are later given in full we shall refrain from entering into detail here, and state only a few of the more important convictions that impressed us after the first week's experience in the orange groves of California.

IMPORTATION OF PARASITES.—The general importance of the introduction of parasites which affect a species in its native land, and which have not accompanied it into the land of its introduction, has been insisted on in our earlier writings and in those of others, and the ease with which this may be done in the case of the more minute parasites of scale insects adds to its importance in their connection. Considering the fearful losses already occasioned to California

orange-growers by two species (the *Icerya* in question and the California Red Scale), introduced from Australia, we know of no way in which the Department could more advantageously expend a thousand dollars than by sending an expert to Australia to study the parasites of the species there and secure the safe transport of the same to the Pacific coast; and the fact that the Commissioner of Agriculture is prevented from doing so by restrictions imposed on the Division of Entomology is a sad commentary on the narrow Congressional policy which seeks to limit and control administrative action in details which can neither be properly understood nor anticipated by committees.

PREVENTIVE ACTION.—The value of clean culture and fertilizing where necesary to induce vigorous growth, but more particularly of wise pruning, so as to let in the sun and rain to the heart of the tree, has been set forth in the special report of the Division on the Insects affecting the Orange, by Mr. Hubbard, and apply equally to California as to Florida. We have also been particularly impressed with the value of wind-breaks of coniferous trees not affected by the Coccidæ that infest the Orange, both as shelter to the trees and as screens to prevent the spread of the *Icerya* from infested trees outside the grove.

SPRAYING WITH INSECTICIDES.—The orange-growers of the Pacific have suffered greatly from the advice and recommendations of biased or interested persons, who were prejudiced in favor of their own particular remedies, and were for a long time unwilling to profit by the results of thorough and careful experiments which we have for some years conducted in the East, and which are in the main embodied in Mr. Hubbard's report. A pretty thorough personal survey of the field has convinced us that while the resin soaps experimented with by Mr. Koebele are a valuable addition to our insecticides for the orange Coccidæ, yet in the main our experience in Florida is repeated in California, and all the more satisfactory washes have kerosene as their effective base. There has been, and is, however, a very great waste in applying it, and where from 10 to 50 or more gallons have been used on a single tree, from 2 to 4 would suffice.

We cannot urge too strongly the fact that in the case of this *Icerya*, as most other orange-feeding Coccidæ, it is practically impossible, with the most careful and thorough spraying, to reach every one of the myriad individuals on a good-sized tree. Some few, protected by leaf-curl, bark-scale, or other shelter, will escape, and with their fecund progeny soon spread over the tree again if left unmolested. Hence two or three sprayings at intervals of not more than a month are far preferable to any single treatment, however thorough; and this is particularly true of the *Icerya*, which occurs on so many other plants, and which in badly infested groves is crawling over the ground between trees. It is now the custom to use the time of a team and 2 men for fifteen to twenty minutes or more, and 10 gallons and upward of liquid on a single medium-sized tree. In this way the tree is soaked until the fluid rains to the ground and is lost in great quantities, some growers using sheet-iron drip-plates around the base of the tree to save and re-use the otherwise wasted material. This is all wrong so far as the oil emulsion is concerned, as the oil, rising to the surface, falls from the leaves and wastes more proportionally than the water.

The essence of successful spraying of the kerosene emulsion consists in forcing it as a mist from the heart of the tree first and then

from the periphery, allowing as little as possible to fall to the ground and permitting each spray particle to adhere. It is best done in the cool of the day, and, where possible, in calm and cloudy weather. With one-fifth of the time and material now expended in California the spraying should be successfully done, so that three sprayings at proper intervals will be cheaper and far more satisfactory than only one as ordinarily conducted. In this particular neither Mr. Coquillett's nor Mr. Koebele's experiments are entirely satisfactory, as we were so far from the field while they were being carried on as to render any special direction of them impossible. Both strove for the practically impossible, viz, the destruction of all insects by a single application. Mr. Koebele's estimate of the cost of the kerosene wash is also too high, as he used it much stronger than necessary. The resin compounds may doubtless be used to advantage in connection with the kerosene emulsions; but anything which will give permanence and preventive character to the wash will add greatly to its value. Without going into details as to reasons, we would therefore recommend the addition to every 50 gallons of the kerosene-soap wash, made after the usual formula, 3 ounces of arsenious acid. Though the arsenical preparations are mainly effective against mandibulate insects, by poisoning through the stomach, they have also more or less effect by contact, and we are strongly of the opinion (which we hope soon to verify) that this combination, for the first time recommended, will give the spray more lasting effect, and that the few insects which escape the direct spray will be destroyed as they subsequently leave their protecting retreats or hatch from eggs and crawl about the tree. As a means of arresting the growth of the black-mold (which is, however, only the indirect consequence of the Coccid), so troublesome an accompaniment of the *Icerya*, a small proportion of sulphate of copper might also be added.

Just as there is now a great wastage of time and material in drenching a tree, so the spraying nozzle most in vogue in California is also wasteful. That most commonly used is the San José nozzle, in which the water is simply forced through a slightly flaring terminal slit in a more or less direct and copious jet. The force and directness of the spray give this nozzle its popularity under the mistaken spraying notions which prevail, and to this we must add the fact that, being a patented contrivance, it is well advertised and on the market.

The cyclone nozzle has not yet had proper trial to impress its advantages, having scarcely been known prior to the experiments of Messrs. Coquillett and Koebele. That made and sold by G. N. Milco is patterned in size and aperture after that which we designed to spray from near the surface of the ground. What is wanted for an orange grove or for trees is a bunch of nozzles of twice the ordinary size and capacity, the size of the outlet to be regulated by the force of the pump. There is no form of nozzle so simple and so easily adjustable to all purposes. We strongly recommend a bunch of four nozzles of twice the ordinary size and thickness, one arranged so as to have the outlet distally or at one end of the piping (which may be ordinary gas-pipe) and the other three on branches, so that the outlet is at right angles, each about an inch below the other, and so placed that they are separated by one-third the circumference of the main pipe. Such a bunch, with apertures properly adjusted to the occasion, worked from the center of the tree, will envelop it in a perfect ball of floating mist, which in a very short time will imbue all accessible parts. For tall trees a more forcible direct spray might be sent

from the end by substituting an ordinary jet and the wire extension, which is simply an extension tube screwed over the nipple, the end of the tube being covered with wire netting, which breaks up the liquid forced through it, and which for force and fine division of the particles has some advantages over the San José nozzle. Finally, if a series of blind caps and several sets of caps of varying aperture are kept on hand, the spray may be adjusted at will, and to suit the conditions of wind, pump force, &c., that have to be dealt with.

FUMIGATING.—Fumigating the trees will always have the disadvantage, as compared with spraying, that the mechanism is more cumbersome, the time required greater, and the first cost in making preparation heavier; and these factors will always give spraying the advantage with small proprietors or those who have to deal with young trees. As an offset to these drawbracks fumigation has the merit of more effectually reaching all the insects upon a tree, and this alone would under some circumstances justify the greater first cost and trouble in preparing movable tents for the purpose, providing always that a gas, vapor, or fume be discovered that will rapidly kill all the insects without injuring the tree; virtues not easily combined in such subtile media.

In Florida proper spraying has been found to be so effectual and satisfactory that no elaborate experiments in fumigating have been undertaken, and we are fully satisfied that proper spraying will also prove sufficient in California. But so much poor work has been done and so many defective washes used that many growers have become discouraged, and quite a disposition has been shown to either cut down the trees or resort to fumigation as a last resource. In connection with Mr. Alexander Craw, Mr. Coquillett has conducted some experiments in the Wolfskill orchard at Los Angeles, which lead them to believe that they have discovered a gas which possesses the requisite qualities, and trees that had been treated and which we examined pretty carefully would seem to justify their hopes. Several ingenious movable-tent contrivances are also being developed in Los Angeles County that give promise of practical utility and feasibility, and which we may have more to say about on some future occasion.

BANDAGES AROUND THE TRUNK.—There is always danger that a tree once sprayed will get reinfested from the insects that have not been reached upon adjacent plants or upon the ground, and which in time crawl up the trunk. Any of the sticky bandages used for the canker-worm will check this ascent, but when placed directly on the trunk may do more harm than good. They should be placed upon strips of tar or other stout paper or felting, tied by a cord around the middle, the upper end flared slightly outward, and the space between it and the trunk filled with soil, to prevent the insects from creeping beneath. Cotton should not be used for this purpose, as birds for nesting purposes carry away particles of it containing the young insects, and thus help to disseminate them.

CONCLUSION.—All possible care should be taken in cultivating and harvesting the crop to prevent dissemination of the young upon clothing, packing-boxes, &c., and too much care cannot be exercised in endeavors to prevent the introduction of the species from infested to non-infested regions. Next to destructive locusts no insect has been more fully legislated against than this *Icerya* in California. Yet while some good has resulted, the laws have too often proved inoperative, either through the negligence or ignorance of the officers appointed to

execute them, or, more often, the indifference of the courts and their unwillingness to enforce them with vigor.

The pest has come to stay. No human endeavor can exterminate it. But it may be controlled, and while the greatest possible co-operation should be urged and, if possible, enforced, yet each orange-grower must in the end depend upon his own exertion; and we say to them, individually and collectively, that there is no occasion for discouragement. This insect has made profitable orange-growing on the Pacific coast more difficult and more of a science; but, by making it impossible at the same time for the shiftless to succeed in their business, it will come to be looked upon as a not unmixed evil.

BUFFALO GNATS.

Order DIPTERA; family SIMULIDÆ.

[Plates VI, VII, VIII, and IX.]

For many years past one of the greatest insect foes the stock-raisers of the lower Mississippi Valley have had to contend with has been the so-called Southern Buffalo Gnat. This insect is a small fly, closely related to the well-known "Black Fly" of the North, to the famous "Columbacz Gnat" of Hungary, and to other less known but as noxious species of the genus *Simulium*, found abundantly in Lapland, Brazil, and Australia. These flies swarm at certain seasons in immense numbers, and by their bite, multiplied a thousand fold, cause great destruction amongst mules, horses, cattle, hogs, sheep, and poultry.

Although we possess in the United States a great number of species of the genus *Simulium*, only a few of them are so very troublesome and noxious as to have attracted special attention. The great majority of the species are quite local, and occur only in such limited numbers as not to form swarms of sufficient strength to occasion any serious damage, although they are very troublesome at times in some regions. The popular name "Southern Buffalo Gnat" includes at least two distinct species, and others will doubtless be found to contribute to the injury when the regions are better studied entomologically. In any general account of the distribution of the Southern Buffalo Gnats it must be borne in mind that these two species are frequently called by the same name, and that even other flies not at all related to them are called Buffalo Gnats by the inhabitants of the infested regions.

Although two or more species of *Simulium* are thus confounded, the following general statements will describe the actions of all species. They resemble each other in their life-history so closely, that one description of it will apply to that of all.

The popular name Buffalo Gnat has not been chosen because these gnats ever attack the animal of that name, but because of a fancied resemblance to the shape of the same. Looking at the insect from the side, it reveals a very large, hump-backed thorax, with the head—furnished with two short antennæ, like minature horns—in the act of butting an enemy. The name "Turkey Gnat," however, has been given to one of the species concerned, because it appears at a time when turkeys are setting and suffer so much by them. "Goose Gnat" is another name used for the same insect for a similar reason.

Believing that it is always best in popular nomenclature to adopt names already known and given by the people, we shall throughout

this article designate the chief depredator as the "Southern Buffalo Gnat" and the second one as the "Turkey Gnat." We shall treat first of the "Southern Buffalo Gnat," but as both species occur to a great extent through the same region, most of what is said of the one species will apply also to the other, their habits being essentially the same. We shall call particular attention to the "Turkey Gnat" only when it is necessary to show any differences, whether as to distribution, habit, or character.

THE SOUTHERN BUFFALO GNAT.

(*Simulium pecuarum* n. sp.)

GEOGRAPHICAL DISTRIBUTION.

The region infested by the Southern Buffalo Gnat is much more extensive than formerly known. In some years at least it comprises the whole of the Mississippi Valley from the mouth of the Red River, in Louisiana, to Saint Louis, Mo. All the land adjacent to the many rivers and creeks that empty from the east and the west into the Mississippi River is invaded by swarms. They are driven about by the wind, and reach points far away from their breeding-places. The exact localities reached by such swarms can as yet not be given, but may be mapped out after further investigations.

In *Louisiana* all the land inclosed by the Mississippi and Red Rivers, with perhaps the exception of the extreme western counties, is usually invaded by the Buffalo Gnats during a gnat year. South of the Red River they become scarce, less aggressive, and appear only at very irregular intervals.

In *Mississippi* all the counties bordering on the river that gives the name to the State are more or less invaded during gnat years.

All *Arkansas*, excepting perhaps the western counties, shares the same fate. In the numerous creeks and rivers of this State and of Louisiana the Buffalo Gnat breeds most abundantly.

In *Tennessee* the same conditions prevail as in Mississippi, but the swarms do not reach so far east as in the latter State.

In *Missouri* the Buffalo Gnats infest only the southeastern counties.

Kentucky does not fare as well as Missouri, since swarms of them frequently ascend the Ohio River for some distance.

Illinois and *Indiana* are also more or less invaded; in the former, it is the region bordering upon the Mississippi and Wabash Rivers; in the latter, that on the Ohio and Wabash Rivers. In 1886 Buffalo Gnats appeared in large swarms at De Soto, in Jackson County, Illinois, and along the White River, in Davies County, Indiana.

In Eastern *Kansas* swarms have repeatedly done great damage.

EARLY HISTORY.

From the very fact that the Buffalo Gnats have been constantly denominated by the same term, inevitable confusion must necessarily exist in their early history. Such is indicated by the appended reports of the special agents, who of course could not tell to which of the species the information received applied.

It seems that no authentic record exists in Louisiana about the occurrence of the Southern Buffalo Gnat prior to the year 1850. It has been reported, however, that they had previously appeared in 1846.

In 1861 and 1862 they were very troublesome in portions of Mississippi and Louisiana; in 1863 and 1864 they abounded about Shreveport, La., and in Chicot County, Arkansas. None are reported to occur in 1865, but in 1866 they invaded the alluvial country between the Arkansas and Red Rivers east of the Washita. In 1873 and 1874 serious injury was occasioned by them in several regions in Louisiana. But in 1882 and 1884 they were more destructive than ever before, doing immense damage to live stock of all kinds. Although not generally very numerous in 1885, they appeared in sufficient numbers in several counties of Louisiana to kill quite a number of mules. In 1886 they appeared generally throughout the whole extent of the region infested by them, and they appeared rather unexpectedly, because it was so unprecedentedly late in the season.

In Indiana this insect was well known as far back as 1843, when the settlers used to watch for it every year, as swarms would appear in certain regions with more or less regularity, often occasioning considerable damage.

It was ascertained from a number of gentlemen in Tennessee and Mississippi that the Buffalo Gnats were well known to their ancestors who first settled in that region at a time when Indians were their neighbors.

But every one questioned in the States of Louisiana, Mississippi, Tennessee, and Arkansas would voice this universal opinion, viz, that Buffalo Gnats come only with high water and are contemporary with an overflow. The connection between an overflow and the appearance of the Buffalo Gnats will be considered farther on.

TIME OF APPEARANCE.

The time of the appearance of the Southern Buffalo Gnat is regulated by the earliness or lateness of spring, and it consequently appears much earlier in the southern parts of the Mississippi Valley. As a rule, it can be expected soon after the first continuous warm spell in early spring. The first swarms were observed last year in Louisiana on March 11; in Mississippi and Tennessee, May 1; and in Indiana and Illinois, May 12. Small and local swarms may appear somewhat earlier or later in the neighborhood of their breeding-places. The Turkey Gnat appears usually later, although in 1886 it appeared near Memphis, Tenn., as early as April 5; the swarms were quite local, however, and strictly confined to the vicinity of creeks that produced them. In Louisiana they appeared, as usual, much later than the true Buffalo Gnat, and some were found as late as June 6, and the bayous disclosed others still in their pupal state.

The great majority of the species of this genus are northern insects, and appear there in the winged form all through the summer. The larvæ require cold water for development. As we go farther south this *cold water* can only be found in the more elevated regions or in winter or the early months of spring. Earliness of season or high altitude are there the substitutes for the lower temperature of more northern latitude.

DURATION OF AN INVASION.

Swarms of Buffalo Gnats usually appear with the first continuous warm weather of early spring. They lead a roving kind of life, being drifted about with the wind, which frequently carries them long

distances beyond their usual haunts. At first the members composing a swarm are very active and blood-thirsty; but they soon die, and the swarm decreases gradually and soon disappears entirely. New swarms appear continually and replace the former ones. The duration of an invasion throughout the regions infested varies from a few days to five or six weeks. If cold weather follow their appearance, the gnats become semi-dormant; they are not killed by it nor by rain, but revive and become aggressive again with the first warm rays of the sun. Hot weather, however, soon kills them and puts an end to any further injury. The duration of life of a single individual is short; at least specimens confined even in large and well-lit boxes soon die. Buffalo Gnats that have once imbibed blood of any animal also soon die, as seen by the large numbers found dried up in stables in which they have been carried attached to mules or horses. In the fields gnats filled to repletion with blood drop to the ground and crawl away, soon to die. They suffer, therefore, from their blood-thirsty habits, and this seems to be quite a general rule with all those blood-sucking species which are known to annoy man and other warm-blooded animals; for the love of blood generally proves ruinous to those individuals which are anxious to indulge in it, as we have shown to be the case with the Harvest Mite or Jigger.*

CHARACTER OF A SWARM.

The number of individuals comprising a swarm cannot be computed, as swarms vary greatly in size. Their presence is at once indicated by the actions of the various animals in the field. Horses and mules snort, switch their tails, stamp the ground, and show great restlessness and symptoms of fear. If not harnessed to plow and wagon they will try to escape by running away. Cattle rush wildly about in search of relief. Formerly, when deer were still numerous, they would be so tormented by these insects as to leave their hiding-places and run away, seeking protection even in the presence of their greatest enemy, man. Approaching animals in the field, we notice at once small black bodies, exceedingly swift in their flight, darting about their victims in search of a suitable spot to draw blood. But even during a very general invasion by these gnats these insects are not uniformly distributed throughout the region infested, but they select certain places. Only low and moist ground is frequented by them; exposed or sunny spots are never visited. There may be no indications of gnats in a whole neighborhood, and the unprepared farmer, dreaming of no danger to his mules or horses in passing dense thickets of bushes, &c., near the roadside, is suddenly attacked by a swarm of these pests, and is frequently unable to reach a place of safety in time to save his cattle. As suddenly as such swarms appear, just as suddenly do they disappear. During a gnat season cautious farmers never travel with their horses or mules without providing themselves with some kind of protective grease.

When Buffalo Gnats are very numerous the whole air in the vicinity of our domestic animals is filled with them at times, and looking towards the suffering brute, one sees it surrounded by a kind of haze formed by these flying insects. Sweeping rapidly with the hand through the air one can collect hundreds of gnats by a single stroke. They crawl into everything, and the plowman has constantly to brush

*See *Amer. Naturalist*, vol. vii, 1873, p. 19.

them away from his face, which does not always prevent them from entering and filling his mouth, nose, and ears; he is so tormented by them, and frequently by their bite as well, that he has to cease working for the time being. Thousands try to enter the houses in villages and cities, and the windows are frequently completely covered with them.

MODE OF ATTACK.

The flight of all species of *Simulium* is very swift and powerful. They possess, in comparison with most other flies, an enormously large thorax, consisting of a very tough, chitinous integument, that furnishes ample attachment for the strong muscles which propel them during their long and continuous flights.

The Southern Buffalo Gnat is exceedingly active in all its motions, and is at its bloody work as soon as it has gained a foothold upon an animal. The individual flight is inconspicuous and rarely more than a few feet from the ground. It is also usually noiseless, but when one passes rapidly close to the ear of a person the sound produced is faintly like that of a passing bullet, and no one who has listened to it will ever forget it, but will always connect it with their presence.

If the insects are not very hungry, or if influenced by too warm or too dry an atmosphere, they circle around a mule or a horse very much like so many small bees; if hungry, however, they lose no time whatever, but with a few nervous jerks settle upon the selected spots and immediately go to work. They are never quiet, but are most active during early morning and towards evening. They also fly during moonlight nights. During the hottest portions of the day, from 11 a. m. to 4 p. m., they are more or less inactive. Their favorite time of attack is a cloudy, dark day, or when rain is threatening. If the gnats try to enter houses or stables by means of the windows, they constantly butt their heads against the panes of glass, until they become so exhausted that they drop to the ground and die. Specimens kept in confinement in large vessels, with the bottoms covered with moss and soil and containing a wet sponge and a saucer filled with water, die within forty hours. During all this time they never cease trying to escape. The sense of smell (and sight) of these insects must be well developed, because they unerringly find animals a long distance away from their breeding-places. If very numerous, they cover the whole animal, without making any selection of position.

The smaller Turkey Gnats are not so blood-thirsty, nor do they form such large swarms. The snorting, biting, switching of tails, and the general restlessness of the stock in the fields soon reveal the presence of their foes. The gnats will, upon arrival, rapidly circle around the animal, select a point of attack, fasten themselves upon the chosen spot, and immediately commence to bite. The genital and anal regions, the ears and portions of body between the forelegs—in short, those parts where the skin is most easily punctured—are selected by these insects. The attack is so rapid, that in course of one minute the body of the tormentor is seen to expand with blood, which shows plainly through the epidermis of the abdomen. The bitten part of the animal shows a nipplelike projection, and if the insect is removed by force a drop of blood as large as a good-sized pin's head will ooze out. Other gnats will almost at once pounce upon the same spot and continue the biting. All those veins which project under the skin of the animal are also favorable points of attack, and their course is made visible by the hordes of gnats fastened upon them.

The great danger of an attack by these insects lies in the unexpectedness of their appearance. As already mentioned there may be no indication of their presence in any neighborhood and the roads are free of them. But with the change of the prevailing wind they may appear, and when one is passing certain localities, such as low, wet, and shady ground, or dense thickets of underbrush, they will start forth like a cloud, and cover the animals at once. Open fields may be entirely free from gnats, but if animals pass certain places in them out dart the tormentors, and the animals attacked can only save themselves by running to high places exposed to the full rays of the sun. The gnats, following the animals for some distance, leave as suddenly as they appeared, and hide themselves again in the thickets. In the cities they appear suddenly with certain winds, chiefly with those blowing from the south, southeast, and west, and usually disappear again with winds blowing from the opposite direction.

ANIMALS INJURED.

Domestic animals are attacked in the following order, varying somewhat in different localities, viz, mules, horses, cattle, sheep, setting turkeys and hens, hogs, dogs, and cats. The death-rate of mules is highest, both because they seem to be more susceptible to the bite, and because they are almost exclusively used in the Southern States for farm work. Horses also suffer greatly. Cattle, when weakened by winter exposure and by scarcity of food, succumb easily to the continued attacks of their winged foes. Hogs show at first the effects of the bite but very little; yet large numbers die soon after the attack, while others die about six weeks after the disappearance of the Buffalo Gnats; they usually perish from large ulcerating sores, which cause blood-poisoning. Many persons claim that the so-called *charbon* is produced by the bites of these gnats, a statement which is, of course, not borne out by facts. Sheep, although well protected by their wool, suffer greatly by bites upon the unprotected portions of their skins, and injure themselves still more by crowding too close to fires, which are built to produce protecting smoke. Many sheep crowd so close to the fire as to be burned to death. Setting turkeys and hens are frequently forced by the gnats to leave their nests. Young fowls are killed outright. The gnats, in attacking fowls of all kinds, force their way under the wings of their victims, where they cannot be dislodged. Dogs and cats are also greatly tormented, and will not remain outdoors during a Buffalo Gnat invasion if they can help it. Deer, forgetful of any other threatening danger, are tormented to such a degree as to lose all fear, and approach the smoldering fires; in their agony they sometimes allow people to rub the gnats from their bodies, and will, in their frantic endeavors for relief, even lie down in the glowing embers or hot ashes.

EFFECT OF THE BITES.

Animals bitten by many Buffalo Gnats show all the symptoms of colic, and many people believe that these bites bring on that disease. Mules especially are thus affected, yet large numbers of *post mortem* examinations made by Dr. Warren King, of Vicksburg, and others, failed to show any relationship between this disease and the bites, nor were any facts obtained which would justify the correctness of such a popular conclusion. Dr. King opines that the effects of these bites

on animals are much the same as that of the rattlesnake on the human system. This seems to be the generally accepted opinion among the more intelligent planters. The animal attacked becomes at first frantic, but within a very short time it ceases to show symptoms of pain, submits passively to the infliction, rolls over, and dies; sometimes all within the space of three or four hours. Even if bitten by a very great number of gnats death does not necessarily follow, and then it is not always suddenly fatal. Mules which at night do not appear to be seriously injured will often be found dead next morning.

Animals of various kinds become gradually accustomed to these bites, and during a long-continued invasion but few are killed towards the end of it. It is a prevailing notion that the bite of the gnats appearing first is the most poisonous. It would seem to be more probable, however, that the poison introduced into the systems of animals—unless sufficient to prove fatal—may to some extent serve as an antidote against that introduced later, and if this poison should remain in the system with any stability, such a fact would also account for native or acclimated stock being less susceptible to the poison from bites than that recently imported. There is no doubt that stock freshly imported from Kentucky to Tennessee and Mississippi is more apt to be killed than that raised in the infested portions of these States, and that, having withstood one invasion, a second one proves fatal but seldom. One reason why Buffalo Gnats appearing very early in the season are more dangerous may be found in the fact that the stock, weakened by exposure during the winter, have had as yet no chance to gain in strength by feeding upon the early vegetation, which it obtains previous to and during a later invasion. Consequently, the resisting power of animals is greater later in the season. Experience has also taught owners of stock how to protect the same, and in comparison with former gnat seasons fewer animals are killed of late. Prof. J. A. Schoenbauer, who wrote nearly one hundred years ago about the Kolumbacz Gnats of Hungary, witnessed the *post mortem* examination of a horse killed by these gnats. Upon dissection it was found that not only was the anus entirely filled with the flies, but also the genital orifices, the nasal passages, and the bronchial tube and its ramifications. A case of this kind must be very exceptional. No doubt gnats will sometimes enter these passages, but as a rule death is not occasioned in this manner. The loss of blood and the terrible irritation of the skin by so many poisonous bites are reasons sufficient to account for the reflex irritation of the nerves and blood poisoning.

HOW ANIMALS PROTECT THEMSELVES.

The different kinds of animals, knowing their tormenters by instinct or experience, have various methods of protecting themselves against their attacks. To run away is the first impulse of all; but it is of no avail, since their enemies are too swift to be outrun.

Horses and mules, if not harnessed or tied, become perfectly frantic, and rush away hither and thither, roll themselves upon the ground, dash off again wildly, and repeat these actions until they become entirely exhausted. If they succeed in reaching an elevated spot free from trees and accessible to the full rays of the sun, they escape further severe molestation.

Cattle act in a very similar way, but instead of searching for higher, sunny spots, they prefer to rush through dense thickets, such

as are formed by canes, and thus rid themselves of many tormentors, but all in vain. If creeks are near by, some find partial protection by immersing themselves in the water.

Hogs also run madly about. If mud is accessible, they do not fail to make good use of that material and wallow in it.

Sheep run about blindly, crying piteously all the time.

Dogs and cats are sensible enough to search for dark shelters in stables or remain in the house.

Poultry of various kinds seek relief by flying in high trees. They assist each other in picking off their tormentors, thus partly freeing themselves.

Deer try to find relief by running away from the gnats.

But all such methods avail but little without the assistance of man. Fires are started everywhere to produce a dense smoke. As soon as the tormented animals notice such smoke they all show their good sense by rushing to it, invariably selecting that side of the fire where the smoke is densest. Here they crowd together, and many are injured by too close proximity to the glowing embers. Nor can they be driven away by hunger; and only during a dark night, or in the brightest light of the midday sun, do some of them venture out in search of food.

PREVENTIVES.

Smudges have thus far proved the best method of protecting animals in the field against Buffalo Gnats. Thoughtful planters are in the habit of collecting and storing during the year all kinds of material that will produce a dense and stifling smoke; such materials are old leather, cast-off clothing, dried dung, &c. As soon as large swarms of gnats appear, and the stock is threatened by them, fires are started in different parts of the plantation, and are kept burning as long as the danger lasts. Anything that will produce smoke is thrown upon the smoldering logs, and the most offensive is considered the most useful. If the time for plowing has arrived, smudges are located in the fields in such a manner that the smoke is drifted by the wind over the teams at work. Such smoke-producing fires are also kept burning in the cities, and they are found in front of every livery and street-car stable, as well as of such stores as employ draft horses or mules. If these animals have to be upon the roads, they may usually be somewhat protected by tin pails in which some smudge is kept, and which are suspended from their necks and from the wagons.

Animals may also be protected with a layer of mud or a coat of sirup. It has been found that animals which have shed their rough winter coat of hair and have become smooth are not as much troubled as others still covered with long hairs. The gnats find it much more difficult to obtain a foothold upon a smooth skin, and the clipping of the hair in early spring is therefore advisable.

Buffalo Gnats have a great aversion to entering dark places, and stables thoroughly darkened are safe places for stock of all kinds in a gnat season. The odor of ammonia prevailing in such stables may also to some extent prevent the insects from entering. Planters with a small acreage, therefore, prefer to keep their horses and mules in the stable instead of working them in the field. For the same reason the owners of livery stables will not allow their animals to be taken outside the city limits if gnats are numerous enough to be dangerous.

But the great majority of planters cannot wait for the disappearance of the pest, and have to resort to other defensive means. Various external applications have been used to this effect: Decoctions of Alder leaves, Tobacco, Pennyroyal, and other herbs, have been tried with a view of preventing gnats from biting mules while at work; but all of them have proven ineffective. At a time when small swarms of Turkey Gnats were tormenting mules plowing in the field one side of the animal was moistened by Mr. Lugger with various insecticides, while the other side was not protected at all. By following the animal and watching the gnats it was soon observed that any offensive-smelling substance would drive the gnats from the protected side to the unprotected one. Kerosene emulsion, pyrethrum powder suspended in water, diluted carbon-bisulphide, and dissolved tobacco-soap were all used in turn, and all seemed to produce the same effect. Several times the whole animal was carefully sponged with the one or the other of the above substances. For a time the gnats would not settle upon the animal; but in the course of two hours the beneficial effect of these insecticides was gone, and the insects were no longer kept away.

Experience shows that the best preventive is grease of various kinds. The following kinds are the most important: Cotton-seed oil alone, or mixed with tar, fish oil, gnat oil; a combination of stinking oils alone, or mixed with tar or kerosene oil, crude coal oil, kerosene oil, kerosene oil mixed with axle-grease, and others. To be effective, the grease must be used at least twice during the day, because as soon as its offensive odor disappears it becomes inoperative. All such applications are of no advantage, however, on stock running at large. Gnat oil is very extensively used, but it is like the rest of the remedies—very apt to remove the hair.* In fact, all these different kinds of oil and grease are more or less injurious to the animals, because a continued coating with them weakens the system.

The employés of the Hudson's Bay Company protect themselves and their stock against the bites of the "Black Fly" by the use of oil of tar, and as long experience has shown it to be a simple and easily applied wash, we strongly recommend its use. A quantity of coal tar is placed in the bottom of a large shallow receptacle of some sort, and a small quantity of oil of tar, or oil of turpentine, or any similar material, is stirred in. The receptacle is then filled with water, which is left standing for several days until well impregnated with the odor. The animals to be protected are then washed with this water as often as seems to be necessary.

As long as stock in the infested region is suffered to run at large, and is neither provided with shelter nor food during the winter months, it will suffer severely from the gnats. Animals well cared for can stand the attacks of the gnats far better, and do not perish as readily. Ill-treated and unhealthy mules and those bruised and cut are the first to die, and the prevailing opinion of intelligent planters is to the effect that well-cared-for mules, if greased twice a day when working in the field, seldom die even when attacked.

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*According to Messrs. Fahlen & Kleinschmidt, chemists, of Memphis, Tenn., "Gnat oil is any kind of stinking oil; it should not contain drying oils, such as *Oleum lini* and *O. gossypii*." They use fish oil, and to increase its perfume add *Ol. animale fœtidum*, 4 ounces to 10 gallons. But since fish oil costs 50 to 75 cents per gallon, some mix it with crude petroleum; this addition, however, has the tendency to kill the hair roots. *Ol. hedeomæ* (pennyroyal) is too costly, and therefore not frequently used. *Fish oil* and *Ol. animale fœtidum* have given the best satisfaction.

REMEDIES FOR THE BITES.

A number of remedies to counteract the poison of the Buffalo Gnats have been tried, but none of them have been sufficiently tested or have proved uniformly effective.

Dr. Warren King, of Vicksburg, Miss., recommends rubbing the affected animals thoroughly with water of ammonia, and administering internally a mixture of 40 to 50 grains of carbonate of ammonia to 1 pint of whisky, repeating the dose every three or four hours until relieved. He claims to have never lost an animal under this treatment, although they were sometimes apparently beyond recovery. This remedy is not generally known, but certainly contains sufficient merit to warrant a thorough and careful trial.

Some planters claim to have cured their stock simply by continued doses of whisky alone and by keeping the sick animal in cool and darkened stables.

Blood-letting is also recommended, both as a preventive and as a cure, but may be considered as of very doubtful utility, except in cases where heroic treatment is required. Mules badly injured and in a dying condition are bled until the blood, which at first is nearly black, appears of a natural color again.

Dying animals have frequently been saved by immersion in the cold water of running streams. Evidently all these remedies have a tendency to allay the fever produced by incipient blood-poisoning.

ATTACKING MAN.

A number of cases have from time to time been reported by various newspapers in the infested region of human beings being killed by these insects. Inquiry has sometimes failed to prove the truth of such reports; yet sufficient facts are on record to show that if the gnats attack a person suddenly in large swarms and find him unprepared or far away from any shelter they may cause death.

Dr. Bromby, in Madison Parish, La., had a case of death caused, he believes, by the gnats. A Mrs. Breeme, having lost, in the spring of 1883, 17 mules of her stock, was suddenly taken sick. She told the doctor that she had been bitten by mosquitoes. She died in great agony from blood-poisoning.

In 1884 several persons were killed by Buffalo Gnats. Mr. H. A. Winter, from near Helena, Ark., while on a hunting trip, was attacked by them one and a half miles from home, while passing some low ground. Running towards a house, he was seen to fall dead. All exposed parts of his body had turned black. Another man was killed near Wynne Station, Arkansas, on the Iron Mountain Railroad.

DAMAGE DONE IN VARIOUS YEARS.

The damage occasioned by Buffalo Gnats throughout the infested region cannot be estimated, owing to the fact that no statistics have ever been collected in a systematic manner. But the loss in certain localities has been immense, and greatest when the insects appeared in the very early spring. Of late years the losses have increased because the country has become more densely settled and not because the bite of the gnats has become more dangerous. The following statements are based on reports from reliable individuals and from records in local papers examined by Mr. Lugger:

As far as can be learned the damage in Louisiana was but slight prior to 1850; but many animals were killed in 1861, 1862, 1863, 1864, and 1866. In this latter year the parish of Tallulah, Louisiana, lost over 200 head of mules, and upwards of 400 mules and horses were killed within a few days in the parishes of Madison, Tensas, and Concordia, all in the same State. In other States they also did great damage. In 1868 many mules were killed in the low lands of Daviess County, Kentucky. Although frequently causing more or less trouble and loss, they did not appear again in such overwhelming numbers until 1872, 1873, 1874, 1881, 1882, 1884, 1885, and 1886. In 1872 it was reported that the loss of mules and horses in Crittenden County, Arkansas, exceeded the loss from all diseases. In 1873 they caused serious injury in many parishes of Louisiana. In 1874 the loss occasioned in one county in Southwest Tennessee was estimated at $500,000. The gnats have been especially injurious since the Mississippi floods of 1881 and 1882; in the latter year they were more destructive to stock than ever before, appearing in immense numbers in Eastern Kansas, Western Tennessee, and Western Mississippi, and the great destruction of cattle, horses, and mules caused by them added greatly to the distress of the inhabitants of those sections of the country caused by unprecedented floods. Many localities along the Mississippi River in Arkansas also suffered severely. In 1884 Buffalo Gnats appeared again in great numbers and were fully as destructive as in 1882. In Franklin Parish, Louisiana, within a week from their first appearance, they had caused the death of 300 head of stock. They were equally numerous throughout the whole region infested, and for the first time in the history of the pest they attacked horses and mules on the streets of the cities of Vicksburg and Memphis. No general outbreak took place in 1885; yet gnats appeared in sufficient numbers to kill quite a number of mules in various parishes of Louisiana, especially in Tensas and Franklin. Buffalo Gnats appeared again in immense numbers in 1886, and extended throughout the entire lower Mississippi Valley, and swarms were even observed and doing damage far away from the region usually invaded. They came very late in the season, and consequently animals were in better condition to withstand their attacks. The damage was great, however, in many localities where planters had not taken steps to protect their stock.

Besides the actual loss by death of their stock, planters lose much valuable time in preparing their fields for the crops. It so happens that the gnats appear at a time in which the ground becomes fit to be prepared for cotton, and as it is very important to give that plant as much time as possible to mature, every day is very valuable in early spring. Planters owning large estates have to use their mules for plowing, notwithstanding the gnats, while farmers on a small scale can keep their animals in the stable, thus protecting them.

POPULAR OPINIONS ABOUT THE EARLY STATES OF THE BUFFALO GNATS.

The early states of both Buffalo and Turkey Gnats were as a rule perfectly unknown to the inhabitants of the infested regions when our investigations began. Yet the great, and in some seasons absorbing, interest taken in them gave rise to many speculations as to their origin. Many theories had been advanced from time to time and were discussed in the newspapers, and no facts had been observed

to throw light upon the many mooted points yet obscure in the popular mind.

From the very fact that the region infested by these insects contains many swamps, it was claimed by many that the gnats originated in them and nowhere else. Others were convinced that low and moist soil would produce them, since it had been observed that such localities would harbor gnats in abundance, and that their swarms would rise from the grass if animals approached.

Even such absurd theories as that the Mississippi water coming in contact with decayed leaves and similar material would spontaneously create them were stoutly maintained by some, while others claimed that the gnats were produced out of mud without undergoing any transformation whatever. There exists also a prevalent opinion among the more intelligent that the eggs are deposited upon grass, weeds, &c., where they remain until the water of an overflow reaches and submerges them, when incubation takes place. In this manner eggs were supposed to remain sometimes for years, or until the necessary conditions for incubation arrived with the cold water of the Mississippi River.

Many larvæ, which are found in large numbers about decayed logs and under rotten leaves in the woods, have given rise to the belief that such were the young of their dreaded foe. The larvæ of a family of flies, the *Chironomidæ*, which occur in vast numbers in all the water of the infested region as well as elsewhere, look somewhat like those of the *Simulium*. Their general appearance and their actions are very similar, and consequently they have frequently been mistaken for the young of the real culprit, and, in fact, were at first mistaken by our agents. But the flies resulting from these larvæ are very different, looking very much like mosquitoes with feathered antennæ; they also swarm in very early spring, but are innocent of any harm to animals.

We reproduce at Plate IX, Fig. 1, a figure of a *Chironomus* larva which was found in the pods of *Utricularia* at Vineland, N. J., by Mrs. Mary Treat. The figure was made by us at Mrs. Treat's request, and was published as Fig. 9, of her article entitled "Is the Valve of *Utricularia* Sensitive?" in Harper's *New Monthly Magazine*, February, 1876, Vol. LII, pp. 382–387. We have also figured on the same plate, at Fig. 2, *a* and *b*, the pupa of the same species and the adult of *Chironomus plumosus*, a species common to both Europe and America, and which was collected in great numbers by Mr. W. H. Seaman at Chautauqua Lake, New York, August, 1886.

HABITS AND NATURAL HISTORY.

THE EGG.—The eggs of the different species of the genus *Simulium* occurring in the lower Mississippi Valley have not as yet been discovered,* but sufficient is known, from analogy with closely allied species in this country as well as in Europe, to indicate the localities in which to search for the eggs of one of the species, the smaller Turkey Gnat, which is so common in the vicinity of small and rapid streams. These creeks descend from an elevated region not inundated by the Mississippi River. They are, however, greatly affected by an over-

* While this report is going through the press, word reaches us at Los Angeles, Cal., from Mr. Webster, who was sent to Louisiana especially to look for them, that the eggs have been discovered by him.—C. V. R.

flow, since the back water arrests the downward current and eventually forces the water back, thus completely filling the creek-beds with turbid river water. In such creek-beds trees of various kinds abound, as well as great masses of dead and fallen timber, too heavy to be floated away. All such projecting points offer sufficient space for the fly to deposit eggs upon, and such places we intend to have closely investigated the coming spring at a time in which the water is highest and in a neighborhood where flies are known to breed.

As mentioned in our report for 1884, Dr. W. S. Barnard has described and figured in the *American Entomologist* (Vol. III, pp. 191–193, August, 1880) the eggs and early states of a species of *Simulium* common in the mountain streams in the vicinity of Ithaca, N. Y. These eggs (Plate VIII, Fig. 7) were found on the rocks on the banks a few inches above the surface of the water, and we give herewith a description of them as a means of facilitating the finding of those of the southern species here treated of. The eggs are deposited in a compact layer; their shape is long ovoid, but on account of their softness and close proximity to each other they become distorted and polyhedral; one end is frequently flattened or concave. Each egg measures 0.40^{mm} by 0.18^{mm} In Hungary the eggs of the Columbacz Midge (*S. columbaczensis* Schönbauer) have also been studied by Edward Tomosvary, and the observations have been published since his death by Dr. Géza Horváth.* It seems that this species is, as far as its habits are concerned, more intimately related to our smaller species than the larger and more dangerous Buffalo Gnat. Its eggs, which are enveloped in a yellowish-white slime and deposited towards the end of May or beginning of June, are also deposited upon stones or grass over which the water flows and in the brooks of the more elevated regions. The female of that species is said to deposit on an average from 5,000 to 10,000 eggs, but no detailed description is given, while we have found only about 500 in the ovaries of our species.

But when and where does the larger and true Buffalo Gnat deposit its eggs? At present nothing is known about it. Messrs. Lugger and Webster left too soon to discover the eggs, because no gnats were expected so unprecedently late in the season; while Mr. Fillion did not reach the affected region until too late. At the time in which the Buffalo Gnat swarms all the low land is flooded and the water in the bayous has reached a depth of 20 and more feet above the usual summer depth of 2 to 5 feet. The water at such a time has spread over thousands of square miles, and only the taller trees are above it. Over such an extent of surface it would naturally be almost impossible to find these small eggs; but it is now known that the members composing the swarms of Buffalo Gnats are all females, which, led by a mad desire for blood, leave their breeding-places not to return again, but to perish in consequence of this appetite. To perpetuate the species, therefore, copulation of the sexes must take place almost immediately after acquiring wings, that is, at or near the places of their birth, which latter the males do not seem to leave at all. Eggs, no doubt, will be found at such places. If deposited anywhere else their chances of hatching, or rather the chances of the newly-born larvæ remaining in the water after the subsidence of the same, would be slight indeed.

It admits of but little doubt that the eggs will hatch very soon after being deposited, for it is not likely, as has been claimed by

*A. Kolumbácsi légy, Dr. Horváth Géza, in Rovartani Lapok, I. Kotet, 10. fuzet, Budapest, 1884.

some, that the eggs will remain dormant for a whole year, or even two and more years, in the place where deposited, only to hatch when reached by another overflow. Such theories are not borne out by any observed facts, and they are, moreover, contrary to the usual habits of similar insects.

Since some of the breeding places of the two species of insects are now well known, the finding of the eggs will only be a question of time.

THE LARVA.—The peculiar aquatic larvæ of both the Buffalo and Turkey Gnats resemble those of the other known species, and their distinctive features will be shown in the closing descriptive portions of the paper. Generally speaking, they are less than half an inch in length, subcylindrical, attenuated in the middle, and enlarged toward both ends; the posterior third of the body is much stouter than the anterior third, and almost club-shaped. The color of the larva varies greatly, and is usually more or less like that of the substance upon which it is fastened; it is marked by two dirty, greenish-gray, irregular spots upon each joint, on a whitish and translucent ground. The head, which is almost square, is yellowish, marked with a few darker spots and lines, and with a pair of small, black, approximate spots on each side that look like eyes, but are not. Besides the usual mouth organs the head possesses two additional brown and fan-shaped bodies, which are usually spread out and kept in constant motion when catching food; they open and close like a fan, and if folded can be partially withdrawn into the mouth. The smooth body of the larva is composed of twelve joints or segments, five of which form the club-shaped anal portion of the body. On the under side of the thoracic portion there is a subconical, retractile process, crowned with a circular row of short and sharp bristles. The anal extremity consists also of a subcylindrical, truncated protuberance, which is crowned with rows of bristles similar to those of the thoracic proleg. The larva possesses no stigmata, but immediately below the anal protuberance, on the under side of the body, there are three short, cylindrical, soft, curved, and retractile tentacles, to which the large tracheæ lead, and which are probably the organs of respiration.

In some of the most mature larvæ two kidney-shaped black spots are visible just above the thoracic proleg, one on each side. If closely investigated with a good lens it is seen that the tufts of filaments serving the future pupa for respiration are already formed under the larval skin. All these filaments arise from the same spot and are branches of a single internal tube.

Habits of the Larvæ.—The larvæ of the different species of *Simulium* are so very uniform in their modes of life that the description of the habits of one will suffice for all.

The most essential condition for the well-being of these aquatic creatures is rapid motion of the water in which they live. Wherever water of such a description is found in the region infested by Buffalo and Turkey Gnats the one or the other species can be found.

The next important condition of a suitable breeding-place is the presence of some stationary material in the water upon which to fasten themselves.

Water in rapid motion is only found in certain well-defined places, either in streams coming from an elevated plateau or in streams meandering through a level country. In the former any sudden bend and any obstruction, no matter how small, will produce accelerated motion of the water; in the latter, sudden bends are the chief cause. In the

former, there are numerous places where larvæ can securely fasten themselves, because large numbers of sticks partly embedded in mud are not disturbed by the rising water. Against such immersed sticks, as well as against fence-rails, &c., which cross such streams, numerous dead leaves are lodged and anchored by the mud. All such obstructions, forming small whirlpools just below them, are places in which the larvæ of the Turkey Gnats are found. Larger submerged logs, wholly or partly submerged stumps, brush, bushes, or any other material of like nature in the larger creeks and bayous give the larvæ of the Buffalo Gnat suitable places to anchor to.

Upon such material they cluster together, and, fastened by the posterior protuberance to the leaf, they assume an erect position, or make their way upward or downward with a looping gait. Frequently attached by a minute thread, they sway with the ripples at or near the surface of the water, often as many as half a dozen being attached by a single thread. While these larvæ make their way up and down these submerged objects with perfect freedom they do not venture above the water, and when about to pupate select a situation well down toward the bottom of the stream.

The larvæ of the Turkey Gnat are more often found fastened to submerged dead leaves in the smaller and more shallow creeks or branches. These larvæ are evidently somewhat social in their habits, as they crowd together upon one leaf in numbers varying from ten to thirty, and, judging from their uniform size, they must be the offspring of the same parent. As the current away from obstructions caused by twigs and leaves, decreases in swiftness, so do the larvæ decrease in numbers, until only a few feet away but one or two can be found. When first found, in early March, they are quite small, but they grow rapidly during the latter part of March and early April. They are quite stationary when not disturbed. Besides being fastened to the leaf by the last posterior segment, they are also securely anchored by a very fine silken thread. When disturbed they loosen their hold at once and float downstream, suspended and retarded by this thread, which very rapidly increases in length while the larvæ are drifting with the current. While thus drifting they jerk about in a lively manner, searching for a new resting-place, and sink to the bottom quite gradually. Owing to their small size, and to the fact already stated, that their color is in harmony with their surroundings or with the leaf upon which they are fastened, these larvæ are difficult to detect in a depth of 3 to 4 inches. When removed and put in a glass vessel they soon settle against the sides of their prison, and can then be studied with a lens.

The larva can move about very rapidly in the manner of a span-worm, but with this difference, that it always remains anchored by means of a thread, which lengthens as the animal proceeds. Being very restless and active in such confinement, it will keep on looping for hours, at a rate of twenty to twenty-five loops per minute. It can move both forward and backward; the forward motion being produced by fastening the single thoracic leg to the side or bottom of the vessel; loosening the anal proleg, bringing it close to the former, and letting the latter go at almost the same moment; the backward motion being simply a reversal. In the course of six to eight hours the larva becomes weak and sickly; it will drop to the bottom of the vessel if disturbed, but will no longer try to escape. All the larvæ thus imprisoned, in repeated trials, died in the course of twenty-four hours. A colony of nearly full-grown larvæ, in a small creek, shared the

same fate when the overflow of the Mississippi River created a back flow and made the water in this creek stationary for some time.

All the creeks and branches in which such larvæ were found by Mr. Lugger descend in beds composed of clay. The Rocky Bottom Branch, a tributary to the Horn Lake Creek, Mississippi, has worn out a bed in a solid deposit of stratified ferruginous sandstone, intermixed with conglomerations of the same substance. The water, 6 to 8 inches deep in normal seasons, even during the summer months, runs over this stony bed in very rapid currents, forming everywhere little cascades, and no better breeding-places for the larvæ of any *Simulium* could be imagined. Yet none could be found, plainly indicating that the species under consideration must be able to fasten to submerged material to find a suitable home.

Food of the Larvæ.—The larvæ of the Southern Buffalo Gnat are carnivorous in their habits, although they do not, perhaps, reject floating particles of a vegetable origin. Their mouth is not adapted for biting off any pieces from a large or solid substance, but is constructed to catch and ingulf small objects. To obtain these the fan-like organs peculiar to these larvæ create currents of water directed towards the mouth. Any small and floating matter drifted by the current of water into the vicinity of these fans is attracted by the ciliary motions of the component rays of the same, and thus reaches the space embraced by them, and they, bending over the mouth, direct the further motions of the particles. If of the proper kind they are eaten, otherwise they are expelled by a sudden opening or parting of the fans. They do not feed, as has been claimed, upon plants which they are unable to bite off or chew, and which do not exist in the water at the time when the larvæ grow most rapidly. A searching investigation of the water in their breeding-places revealed the fact that it was swarming with animal life, and was filled with the larval forms of small crustaceans belonging to various families, but chiefly to those of Coptopods and Isopods. An abundant supply of food must also be found in the presence of immense numbers of fresh-water sponges, polyps, and animalcula. Larvæ of the Southern Buffalo Gnat kept in glass vessels were observed to swallow these minute crustaceans, and none of this food was seen to be expelled again. A number of square diatoms, jointed together in a chain, have also been observed in the intestines of these larvæ by the aid of the microscope. The presence of such quantities of animal food will also account for the observed fact that the larvæ grow so very rapidly during the early spring, since this is the time of the year in which most of the small fresh-water crustaceans spawn and produce living young, and food is, therefore, much more abundant at this season than at any other.

There may be, and very likely is, a connection between an overflow by the Mississippi River and the amount and kind of food produced by it. During the long-continued heat of summer nearly all the swamp-land, as well as the majority of the bayous, dry up, either partially or entirely, and water remains only in small pools, in springs, and in perennial creeks. The animal life in all these places becomes more and more concentrated, while they fairly swarm with small creatures of all kinds, and if the larvæ of the gnats could lead a roving kind of existence, or could thrive in warm water, there would be no lack of food for them at this season. As great numbers of small creatures found in the evaporating and fast-disappearing water possess the faculty of coming to life again even after having been

dried up for a long time, an inundation resurrects vast numbers of them, and brings them furthermore within reach of the larvæ. These, however, are not active during the heat of summer, and an inundation at that time will not affect them at all; but if it should take place early in spring, this additional source of food would soon mature vast numbers otherwise doomed to die.

PUPA AND COCOON.—As soon as the larvæ are fully grown they descend towards the bottom of the water to make their peculiar pouches, and many pupæ are found at a depth of 8 to 10 feet below the surface; others much higher up. But in shallow water they may be found clustered one above the other, just above the bottom of the stream, their instinct having evidently taught them to provide for a sudden fall in the water. Notwithstanding this, with the water falling in the bayous and larger creeks at the rate of 1 foot per day, many pupæ are left high and dry. Those of the Turkey Gnats, which are always found just above the bottom of the smaller perennial creeks, are not thus endangered by a low stage of the water, which rises and falls suddenly with every heavy rain, but remains of uniform depth at other times.

In one of the breeding-places of the Southern Buffalo Gnats, at the junction of Crop and Mill Bayous, in Tensas Parish, Louisiana, Mr. Fillion found immense numbers of the dry and empty pouches as late as June 10, 1886; they were attached to vines, trunks of living trees, and leaves retained by the vines. All these pouches were found near the highest point reached by the overflow, forming a zone or belt from 3 to 4 feet in width. On July 15, the current, very swift in June, had almost ceased to be noticeable, and the stream had decreased from a width of 45 feet to that of 20 feet; the Crop Bayou was partly dry, and no obstructions or vines of any kind reached the water, which flowed in clear dry banks. The belt of dry pouches was at the latter date high above the water, the lowest being found some 13 feet above it, while the highest reached to the mark left by the overflow.

The cocoon or pouch spun by these larvæ is conical, grayish or brownish, semi-transparent, and has its upper half squarely cut off; it is fastened to sticks, leaves, or logs. The larva in spinning does not leave its foothold, but running in the center of its work, uses its mouth to spin this snug little house. In it it changes to a pupa, which has its anterior end protruding above the upper rim. These pupæ are at first of a light brown color, afterwards changing to a pinkish cast, and, just previous to the hatching of the fly, to black. During the first of the coloration epochs they are attached to the vegetable substances upon which the pouch has been fastened by the thoracic filaments, by threads about the body, and by the anal extremity; but during the last two the pupæ hang by the short anal attachment alone to the threads at the bottom of the pouch, and rise more and more out of the pouch, until at last they swing about freely in the current, attached only by the drawn-out threads.

The pupa itself is distinguished from most other Dipterous pupæ by the presence of a tuft of respiratory filaments starting from each side of the thorax. These tufts, as already stated, foreshadowed by two dark spots upon the sides of the thoracic segments in the larva, are composed of a greater or less number of very slender filaments, varying in number in the different species of *Simulium*. Along the posterior margins of each of the third and fourth dorsal segments there are eight minute spines; the tip of the abdomen is also armed with two larger and bent spines or hooks, by which the pupa is secured to

the inside of the open pouch. Remaining but a very short time in the pupal state, prolonged or shortened by atmospheric influences, they give forth the winged insects. The length of the pupal state in the case of the Turkey Gnat averages five days. Both larval and pupal skins remain for some time in the empty pouch.

The perfect insects issue from their pupæ under water, and surrounded, according to some writers, by a bubble of air. The silky hairs of the fly, however, are protection enough to prevent it from drowning. The winged insect pops to the surface like a cork, runs a few inches over the water, and darts away with great swiftness.

THE IMAGO.—The perfect fly varies in length from 3^{mm} to 4.5^{mm}, the females being usually the larger; the Turkey Gnat is somewhat smaller. Both insects are, like all other species of *Simulium*, characterized by their peculiar short and thick shape. The head is bent under, and is nearly as wide as the very large and humped thorax. The thick antennæ are composed of twelve stout joints; the four-jointed palpi terminate in long and fine joints; the posterior shanks and the first joint of the hind tarsi are somewhat dilated. The free labrum is as sharp as a dagger, and the very prominent proboscis is well adapted for drawing blood. The insects possess no ocelli, but their eyes are large; in the male they join at the forehead, but in the female they are farther apart. The mouth organs of the male are also not so well developed as in the female, being soft and unable to draw blood. The bodies of these gnats are quite hard and can resist considerable pressure. The color of the Southern Buffalo Gnat is black, but covered with grayish-brown, short, and silken hairs, which are arranged upon the thorax in such a manner as to show three parallel longitudinal black stripes; the abdomen is more densely covered with similar hairs, and shows, furthermore, a dorsal broad, whitish stripe, which widens towards the posterior end. The legs are more reddish, but also covered with hairs of the same color as elsewhere; the balancers are yellowish-white and the wings ample. The general appearance of the Turkey Gnat is very similar, but it is lighter in color.

The gnats are exceedingly active, and endowed with very acute senses, which enable them to find unerringly animals a long distance away. Only females seem to form these aggressive swarms, since not a single male has been found in the large numbers captured and investigated. The male stays near the place of its birth, and since females once gorged with blood do not and cannot return, copulation and the depositing of eggs must take place very soon after emerging from the water. These points have as yet to be investigated.

NUMBER OF BROODS.

All species of the genus *Simulium*, the life-histories of which have been studied, are single-brooded, and no doubt Buffalo and Turkey Gnats form no exception to that rule. Extending as they do over such a vast area, we should expect their swarms in some seasons to form and appear continuously for five or six weeks before the whole brood had matured and disappeared. No Buffalo Gnats have ever been found in the infested region during the summer, fall, or winter, even when inundations have occurred in these seasons, and there are no indications of a second or third brood in the same year.

ENEMIES OF THE BUFFALO GNAT.

The Buffalo Gnats in their winged form have but few enemies among birds, because they usually appear at a time in the early spring when but few of our insectivorous birds have returned from their southward migrations. Besides the Mocking-bird and the Winter Wren, birds which remain in the more southern portions of the infested regions, no other birds have been observed to catch and feed upon them. Hens and chickens eat large numbers of such gnats as have become helpless by being gorged with blood. A single premature Dragon-fly, or Mosquito Hawk, and a brightly colored Hawk-fly (*Asilidæ*) were observed by Mr. Lugger to catch them in the fields. But the larvæ of the gnats do not fare so well. Although somewhat protected by their color and position in the water, many are discovered by small fishes belonging to the family *Cyprinidæ*, which frequent even the smallest creeks, and greedily eat them; other fishes in the larger creeks will probably act in the same way. The carnivorous larvæ of Water-beetles, as well as other aquatic insects, no doubt find them as well suited to their taste. The pupæ escape detection much better, because they do not move, and are, as a rule, hidden by the fine floating mud of the water which partially covers them and their pouches.

No insect enemies of any of the *Simulium* larvæ have been heretofore observed either in this country or in Europe. It is therefore interesting to note that the larva of a species of the neuropterous genus *Hydropsyche*, has been found by Mr. Howard near Washington feeding upon the larvæ of a local species of *Simulium*. The facts were communicated by him to the Entomological Society of Washington at its September (1886) meeting, and we quote his account of his observations:

> In the month of August, on the larger stones in parts of Rock Creek, District of Columbia, where the current was swiftest, and particularly on such rocks as were tilted so as to bring a portion of the surface close to the surface of the water, were observed hundreds of peculiar funnel-shaped larval cases or webs (Plate IX, Fig 5) of a species of this interesting Trichopterous genus. The cases varied greatly in size. The mouth of the funnel in some instances was not more than 3^{mm} in diameter and in others reached fully 10^{mm}. The tube of the funnel was in every case bent nearly at right angles with the mouth, and the larva ensconced within it waited for its prey to be caught in the broadened mouth. It was noticed that the cases were preferably placed at the edge of slight depressions in the rocky surface, so that the tubular portion was protected from the full force of the current. The broad funnel-shaped expansion was woven in wide meshes with exceedingly strong silk, and was supported at the sides and top by bits of twigs and small portions of the stems of water plants. The central portion was so open as to allow the water to pass through readily. The tube was strong and tight and was covered with bits of leaves and twigs. It was open at either end. On the surface of a rock about 18 inches in diameter 166 of these nets were counted. At this portion of the stream the larvæ of a *Simulium* (probably *S. venustum*, Say) were very abundant. They occurred chiefly on the small water plants which grow in these rapid places, and were found in considerable numbers on the surface of the rocks on which the cases of *Hydropsyche* occurred. They must have been washed into the mouths of these nets in great numbers, and probably furnished the principal food of the carnivorous larvæ. The *Hydropsyche* larvæ (Plate IX, Fig. 3, and enlarged head, Fig. 4) were very active and difficult to capture, unless the stones were removed entire from the water. Placed in standing water they fought vigorously with each other, and after a lapse of twenty-four hours did not seem appreciably affected by the want of fresh water.

Miss Cora H. Clarke has described the nets of a similar species of *Hydropsyche* (Proc. Bost. Soc. Nat. Hist., vol. 22, May 24, 1882), but does not mention the insects which formed the food of the larvæ observed by her.

DESCRIPTIVE.

There are some characters which these two species possess in common with all other species of the genus, though scarcely any of the described species are known in both sexes. It may be well to state, therefore, that the male differs markedly from the female in his much smaller abdomen and relatively larger thorax, by the mouth parts being soft and subobsolete, and more particularly by the eyes being confluent and having two well-marked and distinct sets of facets. As we have already stated, the male is not found flying with the female, and we should not have obtained this sex in the two species here treated of had they not been bred from the larvæ. It is desirable to describe both sexes from fresh and living specimens, as they become sordid in alcohol, and shrink and lose much of their character and color when mounted dry. The females are also somewhat altered in appearance after having been gorged with blood. The prothoracic is the only spiracle traceable in the insects of this genus.

The larvæ of all the species known have very much the same general form and structure, and they differ chiefly in some of the details of the flabelliform fan and of the mouth parts.

The pupa in form foreshadows that of the future fly, and the species differ in this state chiefly in the number of filaments or ramifications thereof that compose the breathing organs. These are invariably situated, one on each side, upon the anterior dorsal margin of the thorax, each originating in a single trunk, which soon branches into rays which are fine hollow tubes, apparently composed of rings, and closed at their extremities. Each tube consists, further, of one or two chitinous layers covered by a finely granulated material. In both the species under consideration there are two of these chitinous layers, of which the inner is very thin and smooth, the outer thicker and furnished with pores. The base of the trunk connects by a stigma-like ring with a true spiral tracheal tube visible beneath the epidermis, and which, bending suddenly inwards, contracts and connects with the internal tracheal system of the corresponding side.* At the tip of the last abdominal segment, upon the dorsal surface, are two hooks, which engage in the meshes of the cocoon, to hold the pupa in position. Some few threads of loose silk and the old larval skin are also found in this situation. Minute black hooks, arranged in regular and definite order upon the dorsal and ventral surface of the abdomen, assist the pupa to keep its position inside the open cocoon. These hooks are usually bent upwards.

The cocoons of the various species differ from each other both by their structure and by the method by which they are fastened to plants, stones, &c. Generally speaking, the cocoon is a brownish, obconical, semi-transparent pouch, open above, more or less covered with mud, and directed against the current of the water. The pupa is more or less tightly surrounded by it, and has the anterior portion protruding above the rim of the pouch. The cocoons are formed of irregular threads, which harden rapidly in the water, and in the deeper parts of the cocoons there are also some long loose and disconnected threads.

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* Dr. Vogel, in his description of the tracheal tubes of the pupae of *Simulium*, gives a similar description, stating that, contrary to the published opinion of Siebold, there are no tracheæ inside the tubes.—Mittheilungen der Schweizerischen Ent. Ges., Vol. VII, Heft 7.

SIMULIUM PECUARUM, n. sp.—♀. (Plate VIII, Fig. 3, and dorsal view, Fig. 5). Length, 2.5 mm to 4 mm. *Head* (Plate VIII, Fig. 2), uniform grayish-slate, clothed with short yellowish hair, which becomes longer behind the eyes; eyes black, with coppery or brassy reflections; *antennæ* black, with whitish pubescence, and with a few bristles on two basal joints, which are tinged with red; joints 1 to 11 gradually diminishing in thickness towards the last, joint 1 shortest, joints 2 and 3 twice as long as joint 1, joints 4, 5, and 6 as long as joint 1, joints 7, 8, 9, and 10 gradually increasing in length, last joint fusiform, twice as long as joint 10; maxillary palpi a little longer than antennæ, blackish, with long grayish bristles. *Thorax* grayish-slate, more or less densely covered with short yellow hairs, and with usually very distinct markings, consisting of two mediodorsal and two subdorsal, broad, longitudinal, sooty-black bands, of which the latter curve to posterior edge of patagium, which is reddish at tip; lateral edges of prothorax with fine black sutures; under side of thorax uniform grayish-slate, with sparse yellow hairs; space around the one large stigma lighter; halteres opaque, reddish-white; legs uniform reddish-brown, densely covered with yellowish hairs; tips of tarsi blackish: wings subhyaline; larger veins and base reddish-brown. *Abdomen* nine-jointed, joints subequal in length, except the last 2, which decrease in length; a longitudinal, broad bluish-gray dorsal band extends from near base of segment 2, where it is broadest, to the tip, curving downward to the anterior lateral edge of segment 7, below this band laterally the color is blackish-brown, with the exception of a broad bluish-gray transverse band on the posterior edge of each of segments 1 to 6; under side of abdomen uniform brownish-gray, without markings; abdomen densely covered with yellowish hair, which is very long upon the posterior edge of segment 1, forming an overlapping fringe.

♂.—Length varying from 1.5mm to 2.2mm. Differs considerably from female. *Head* (Plate VIII, Fig. 1,) not visible from above, being occupied by the very large confluent eyes; the remaining parts below the eyes are black, with black hairs and bristles; eyes composed of two different kinds of facets, those above being very large, as large again as those of the female, and those in front and surrounding the dwarfed trophi very minute, the dividing line between the two sizes being abrupt [the figure is not accurate]; antennæ similar to those of female, more pronounced in color, both the black and reddish being more vivid; maxillary palpi black, and shorter than the antennæ. *Thorax* black above, with sparse yellow hairs; legs somewhat lighter in color, tips of tarsi not black; hairs upon legs longer than in those of female. *Wings* hyaline, veins and base yellowish-brown. *Abdomen* black, with grayish-white posterior margins to segments, dorsally and laterally, and covered with longer yellowish hairs.

Described from two bred specimens.

Larva (Plate VI, Fig. 1 and Fig. 2, showing head in three positions).—Average length when full grown, 7mm to 8mm. Subcylindrical, the club-shaped posterior third of body being twice as stout as the thoracic joints, and joint 4 the most constricted. Translucent when living, dirty white in alcohol; immaculate in a very few specimens; distinctly marked in the great majority with brownish dorsal cross-bands in middle of joints, leaving free a white mediodorsal longitudinal line; thoracic joints with three irregular rings of the same color; under side more or less irregularly spotted with brown. *Head* subquadrate, horny, yellowish-brown, with a number of brown spots and lines in regular order (as in figure) and two roundish approximate ocellate black dots on each side under the skin, and seemingly rudimentary organs of sight, from which the future compound eyes originate: *antennæ* (Plate VI, Fig. 5 *a*) uniformly pale, three-jointed, about one-third as long as greatest width of head; joint 1 very stout, fully four times as thick as 2, which is a little longer than 1, straight, slightly tapering towards tip, joint 3 extremely small, a mere triangular tip: *mentum* (Plate VI, Fig. 3 *a*) subtriangular, with apex cut away and replaced by three groups of very small teeth, of which the central group consists of three teeth, the middle one largest, and the groups on side, of four teeth, of which the second from center is largest; sides of mentum, near apex, with two small teeth each; all the teeth are chitinous and black, a long erect bristle, pointing upward and inward, near each side of mentum: *labrum* (Plate VI, Fig. 3 *b*) horny, densely covered with hair: *mandibles* (Plate VI, Fig. 5 *b* and *c*) resembling in shape the profile of the inverted last joint of the human thumb, with a series of teeth in place of the nail; teeth difficult to see, owing to the presence of five distinct brushes of hair; upon extreme lower tip of mandibles three large teeth, below them a series of eleven slender and very pointed teeth, of which the first two are the smallest, teeth 3 to 9 increasing and teeth 10 and 11 gradually decreasing in length: a second series of teeth below them consists of two triangular teeth, of which the first is largest: *maxilla* (Plate VI, Fig. 6) stout, fleshy, with an internal thumb-shaped lobe; *maxillary palpus* two-jointed, first joint cylindrical, second very short, crowned with a regular circular

row of short spines or warts: *labium* (Plate VI, Fig. 3 *c*) horny, with two brushes of hair above, between which is a very small *ligula* covered with a small brush of hairs; *fans* (Plate VII, Fig. 1) composed of a stout stem, bearing about forty-six scythe-shaped rays, lined on the inside by very minute, equidistant, erect hairs of equal length. *Thoracic proleg* (Plate VI, Fig. 4) faintly four-jointed, subconical, retractile (introversible), very thin and transparent, crowned with about twenty rows of short, sharp hooks, apparently arranged in a circular manner; the hooks, of which ten are in each row, seem to be movable to a certain extent, and are fastened or hinged to small chitinous rods in the epidermis. *Tip of abdomen* (Plate VI, Fig. 7) formed by a subcylindrical body, crowned with rows of hooks. *Breathing organs* below these hooks and on the upper side of abdomen; they consist of three short, cylindrical, soft and retractile tentacles, which connect with the large internal tracheæ (Plate VI, Fig. 7).

In full-grown larvæ a spot more or less dark (as in our figure) is seen on each side of thoracic joint; it is produced by the formation of the coiled breathing tubes of the future pupa.

Pupa.—Average length, 5^{mm}. General color, when fresh, honey yellow; prothoracic filaments brown, and the abdomen dorsally also tinged with brown, except a mediodorsal space; all the members have also a fine brown marginal line. Prothoracic filaments consisting of six main rays issuing from the basal prominence and subdivided two or three times, so that in most cases as many as forty-eight terminal filaments can be counted. Abdominal joints 3, 4, and 5, each with eight well-separated dark-brown and anteriorly-recurved hooks (Plate VI, Fig. 8), the four on each side separated by a mediodorsal space; those on joint 3 less conspicuous than those on joints 4 and 5; joint 6 without armature; joints 7, 8, 9, and also subjoint less distinctly armed near anterior margin with a continuous dorsal row of very minute posteriorly recurved points; ventrally joints 6, 7, and 8 have each four very minute anteriorly recurved hooks.

Cocoon.—Average length, 3.5^{mm}. Not completely made and not entirely covering the pupa, but tightly surrounding its larger portion. Shape very irregular, with no distinct rim at the upper edge, which is more or less ragged. The threads composing it are very coarse, and the meshes rather open and ordinarily filled with mud. Not always fastened separately to objects, but frequently crowded together, without forming, however, such coral-like aggregations as in some of the Northern species.

SIMULIUM MERIDIONALE, n. sp.—♀. Length, 2.5^{mm} to 3^{mm}. (Plate VIII, Fig. 6.) *Head* uniform slate-blue, verging to greenish or cerulean blue in some lights, clothed with silvery pubescence, which becomes longer behind the eyes; parts below antennæ and trophi more densely pubescent, producing the effect of a white face; eyes with a metallic, coppery luster: antennæ black, with very dense white pubescence; no bristles on basal two joints, which are but very slightly tinged with red; joint 1 shortest; joints 2, 3, and 11 subequal in length; joint 3 widest; joints 4 to 9 subequal in length; joint 10 but slightly shorter than joint 11, which is fusiform; joints 3 to 11 gradually decreasing in width; maxillary palpi as long as antennæ, blackish, with long whitish bristles. *Thorax* slate-blue, with less dense silvery-white pubescence; markings quite distinct, producing the effect of a sculpture, and consisting of three black longitudinal lines, the median narrow, widening a little at apex, and the outer ones curving inwards at base and outwards near apex, sometimes reaching to base of patagium, which appears whitish on account of dense pubescence; on the lateral edges of prothorax are fine black sutures; under side uniform slate-blue, with sparse pubescence; space around the large stigma almost white: halteres white, very faintly tinged with red. *Abdomen* nine-jointed, joints subequal in length, except the last two, which decrease; markings entirely different from those of *S. pecuarum*, formed by velvety black, dark blue and bluish-white, almost silvery, colors; the dark blue appears upon dorsal surface of the last five segments, spreading from a roundish median spot on 5 to the immaculate blue of the last two segments; segments 2, 3, and 4 have each a black cross-bar, and 5, 6, and 7 two narrow black submedian stripes, which disappear almost entirely upon 7; the bluish-white forms an outer edge to all the black and extends over the whole lower surface of abdomen, with the exception of more or less well-marked black cross-lines in middle of each segment; a bluish-white or silvery pubescence covers the entire abdomen, but is very sparse upon the dorsal parts. *Legs* brownish-black; tarsi almost black, and more or less densely covered with whitish hairs. *Wings* subhyaline, veins bluish-white, base ferruginous.

Described from many bred and captured specimens.

♂.—(Plate VIII, Fig. 4.) Length 1.5^{mm} to 2^{mm}. Very different in appearance from female. *Eyes* confluent, very large, brilliant coppery; a very marked difference in the size of the facets, those on upper surface being very large and metallic-coppery, those below and surrounding trophi becoming suddenly small, black, with bronze

reflections; *trophi* reddish-black, dwarfed; *antennæ* black, with light yellowish-brown pubescence in front. *Thorax* above intense black, velvety, with a bluish luster; under side grayish. *Legs* reddish, with black tarsi; *wings* hyaline, veins and base bluish-white. *Abdomen* above black, with posterior margins of segments edged with gray; under side of segments 2 and 3 light reddish-gray, the others blackish with gray posterior margins. Sexual organs black. Thorax and abdomen very sparsely clothed with white pubescence.

Described from three bred specimens.

Larva.—(Plate VII, Fig. 2.) Length when full-grown 5.5mm to 7mm. Normal shape and general appearance. Differs from *S. pecuarum* by the much more irregular markings of segments and head. A majority of the larvæ possess one or two lateral spots on club-shaped posterior third of body. *Head* lacks the regular arrangement of spots and lines, which become confused; the two black spots on each side present. *Antennæ* (Plate VII, Fig. 3*a*) uniformly pale, much longer than in *pecuarum*, slender and 3-jointed; first joint almost twice as long as joints 2 and 3 together, and a little bent; at base three times and at tip twice as thick as second joint, which is nearly uniform in width, tapering but very slightly towards tip; joint 3 small and pointed, about one-fifth as long as joint 2. *Mentum* (Plate VII, Fig. 4) similar to that of *S. pecuarum*, but distinguished by a flatter apex, by the possession of three erect bristles on each side, starting from round pores, which decrease in size towards base; a fourth very small bristle close to base and in line with the bristles above; the sides of mentum have on each side four sharp teeth. *Labrum* and *labium* not different from those of *pecuarum*. *Mandibles* (Plate VII, Fig. 3*b* and 3*c*) possess but seven teeth in first row; the three first nearly uniform in length; teeth 4 to 7 gradually decrease in length; tooth 4 much the longest of all; the two teeth in second row similar to those of *pecuarum*. *Maxillæ* and *maxillary palpus* also similar. *Fans* similar, but the hairs lining the inside of the scythe-shaped rays are thicker and nearer together. *Proleg* more slender; last joint bearing a crown of hooks, usually bent suddenly toward head. Tip of abdomen similar to that of *pecuarum*. *Breathing organs* (Plate VII, Fig. 5) quite different; the three main trunks branch each six times, and the branches enter the trunk from both sides. Full-grown larvæ show also the newly formed coiled breathing tubes of the pupæ through their skin.

Described from many specimens.

Pupa.—(Plate VII, Fig. 6.) Average length, 3.5mm. Shape and coloration as in *S. pecuarum*. The thoracic filaments consist only of the six original rays, which do not branch. Upon dorsal surface of the posterior margins of abdominal joints 4 and 5 is a row of eight anteriorly curved hooks similar to those of *pecuarum*, but none on joint 3; anterior margins of joint 9 and of subjoint with a continuous row of smaller anteriorly curved hooks; joints 7 and 8 unarmed dorsally; ventrally joints 6, 7, and 8 have each four minor hooks.

Cocoon.—(Plate VII, Fig. 6.) Length, 3.5mm. Neater than that of any other species known to me, being formed of fine threads, lined with gelatinous ones. The web is quite dense, uniform, with well-defined, sometimes thickened rims. The cocoon is always securely fastened singly to leaf or stick, and even if many are fastened upon the same leaf they do not crowd each other. It fits snugly about the pupa, which is so securely anchored inside as to be with difficulty extricated.

REMEDIES TRIED AND PROPOSED AGAINST THE LARVÆ.

The results of a number of different experiments with insecticides upon the larvæ of the Buffalo Gnats made by Mr. Lugger during the early spring indicates that it is nearly if not quite impossible to reduce their numbers by killing them in the streams. To attempt to do so when all these streams are swollen, and frequently from 10 to 20 yards wide and half as deep, would be sheer waste of time. When the water is very low and much more sluggish in its motion, thus bringing the chemicals in contact with the larvæ, an application of them might be more effective. Great caution must be used in any efforts in this direction, however, as both man and beast are in many localities entirely dependent upon these streams for their water supply and the introduction of poisonous substances might cause much trouble.

Some of the experiments were made by confining the larvæ in glass tubes and submitting them to a current of water to which the following decoctions and solutions had been added, viz: China berries, salt, lime, sulphur, tar water, kerosene emulsion, and carbon-bisul-

phide. Strong tar water killed them; diluted it proved harmless. Kerosene emulsion diluted to contain 5 per cent. kerosene was effective; three ounces of carbon-bisulphide in 7 quarts of water proved fatal within ten minutes; the other insecticides were ineffective. It would be very costly to put enough of these materials in the water to produce the desired effect.

Other experiments in smaller creeks, in which numerous larvæ of the Turkey Gnat were observed, were carried out in a different way. The materials tried were freshly burned lime, emulsion of kerosene, powdered pyrethrum, carbon-bisulphide, powdered cocculus indicus, and tobacco soap. With the exception of the lime, which was thrown into the water in pieces of the size of an Irish potato, all the others were in a watery solution or suspension. Repeated trials with all the chemicals produced the same effect. As soon as the larvæ came in contact with any of the insecticides they would immediately loosen their hold upon the leaf and drop down-stream. When the insecticides became so much diluted as not to incommode the larvæ any longer, these would again fasten to leaves. By using a larger amount of the various substances many larvæ were killed, as well as most of the small fish and aquatic insects.

But if the breeding-places in the creeks have to be searched out to apply the insecticides, it would be much more simple to remove all the logs, sticks, and leaves. All the fences across the branches should be removed, or rather should be replaced by wire fences, which would neither impede the current nor catch as many sticks and leaves. Logs and larger twigs, if not embedded too deep in the mud of the creek bed or banks, will always be removed by any high water; a very common occurrence in the Buffalo Gnat region. Old leaves, made heavy by the adhering mud, would also be carried away by any high water if the obstructions in these creeks were removed, and with these sticks and leaves many if not most of the larvæ would be carried away either into the main rivers or the lower level of the creeks or lakes, where there is no current and where they would soon perish.

If the general opinion that broken levees are to blame for the destructive swarms of Buffalo Gnats prove to be the correct one, the restoration of such levees would, within a few years at most, restore the former immunity from these insects. This time would be materially hastened by the removal of obstructions in all such parts of the bayous where they would come in contact with the swiftest current.

OVERFLOWS AND BUFFALO GNATS.

It is very generally claimed by the inhabitants of the infested region that as long as the States bordering upon the Mississippi River had a perfect levee system, which prevented the water from escaping into the inland bayous, no damage was occasioned by Buffalo Gnats, not even in districts now badly infested. It is further claimed that the Buffalo Gnats appear with every overflow, and only with an overflow if such overflow occur at the proper season and with the proper temperature, viz, during the first continuous warm days of March, April, or May.

The chronological data already given seem to prove such assertions correct. Too much weight should not, however, be attached to these data. The region is as yet rather thinly settled, and no systematic records of the appearance of Buffalo Gnats in injurious numbers have ever been kept. A general and widespread appearance of these

insects seems to take place, however, only during an inundation, and, granting the connection between the two phenomena, the causes for it are yet obscure. It was by the elucidation of this problem that we hoped to discover some means of preventing the injury of the flies by preventing the multiplication of the larvæ.

Inundations in the lower Mississippi Valley are not occasioned by local rains, but by the immense volume of water brought down by the river and its more northern tributaries, and such overflows first take place in the northern regions infested by the Buffalo Gnats, and not in the southern. The earlier appearance of these insects in the South would seem to invalidate the prevailing belief that an overflow brings them. Similar conditions prevail in Hungary, where a closely allied insect does so much injury to all kinds of live stock. There the gnats appear every spring in varying numbers, forming local swarms which move about with the wind: but no general invasion takes place until the river Danube inundates the region infested.

Is it not probable that swarms of these gnats are forced by the conditions consequent upon an inundation to extend their flight beyond their usual haunts to the more elevated and drier regions, and that in this fact we have at least one of the causes of the connection? Small swarms, otherwise local and unobserved, would thus, during a period of high water, be forced to band together in such immense armies. There must be other reasons, not yet clearly demonstrated, why these insects appear in such vast swarms with an overflow, and this problem can only be solved by a critical study of many breeding-places during several seasons over the whole region involved.

Some peculiarities of the swarms of Buffalo Gnats have been observed, and these may, by closer study in future, throw some light upon the problem. It is to be noted that all the specimens composing these swarms are females, and that not one male has been found among them either here or in Europe. There is every reason to believe that none of the females composing the blood-thirsty swarms return to the localities where they were born and developed. Experience indicates that once gorged with blood they die. The swarms dwindle in proportion as they are carried away or move from their breeding-places.

Close investigation with the microscope has failed to reveal any eggs in the ovaries of the females composing these swarms, and if they deposit eggs at all it is before congregating to attack animals.

These singular facts invite speculation and theory, but it were unwise to indulge in these before we have learned more about the eggs, when and where deposited, and whether the females depositing them are in any way different from those comprising the swarms. Dr. Fritz Müller has published in the *Archivos do Museu Nacional do Rio de Janeiro*, Vol. IV, p. 47, pl. IV–VII,* some very interesting observations on another fly (*Paltosoma torrentium*), the larva of which is only found in the torrents and cascades of certain streams descending the mountains of Brazil. There the pupæ fastened by the flat venter to the rocks under water, and change into the perfect flies. He found by opening the mature pupæ that there are always two forms of females associated with one form of male. The one form of female possesses a rudimentary mouth, only fit to sip

* Reviews of his paper appeared in *Kosmos*, Vol. VIII, pp. 37–42; *Nature*, July 7, 1881, p. 214; *Entomologist's Monthly Magazine*, February, 1881, p. 206 and pp. 130–132, and March, 1881, pp. 225, 226.

honey while the other has a mouth well adapted to penetrate, the skin of warm-blooded animals and to suck blood.

The male *Simulium*, so far as known, is only found near where it developed. The structure of its mouth prevents it from biting, and it shows no inclination to join the roving swarms of females. Hence pairing of the sexes must take place in the vicinity of birth, and the eggs are probably deposited soon afterwards. It is also possible, as in the case of other Diptera, that the eggs are already well developed in the pupa.

The condition of the inundated region forbids an indiscriminate selection of places to deposit in, since the young larvæ must in time find suitable swift currents of water after the subsidence to the normal level. Such breeding-places we hope to be able to map out in future.

It has also been claimed that a number of successive broods of the Buffalo Gnat appear in early spring. If such were the case the relationship between the presence of the gnats and an overflow could be very readily imagined; but we have already shown that there is absolutely no proof thus far of more than one annual brood.

Mr. Webster, while studying in the neighborhood of Vicksburg last spring, was impressed with the idea that the connection between the *Simulium* increase and overflows was dependent upon the condition of the levees, in that the river water in swelling the waters of the bayous not only creates a stronger current in the main bayou, but brings the current in contact with many trees and shrubs, as well as stumps and vines, along the bayous, thereby offering much greater chance for the larvæ to attach themselves.

While we were at first inclined to give some weight to this view, and it seemed to afford an additional important argument in favor of keeping the levees in good condition, a survey of the whole field leads us to abandon this as the most important cause in the increase of the gnats during the period of the overflow, and to adopt the theory already advanced, viz, that the connection is at least partly due to the gnats being driven by the advancing waters from the lower to the higher lands.

Another theory, not supplanting this last but supplementing it, we would advance here: There is no doubt but that the advance of the waters from the main river and their commingling with the clearer streams and tributaries carry a suddenly increased food-supply, in the way of minute crustacea and other aquatic creatures, to the *Simulium* larvæ just at the season when these are about to transform. It is quite probable that development in these larvæ remains more or less latent or stationary during the cold winter months or when the water in which they occur is depleted of minute animal life, and that a sudden access of food would accelerate the final transformations.

A possible third connection between the overflow and this increase may arise from the fact that the larvæ, when the water rises, leave their attachments, or that the débris upon which they are fastened becomes itself started by the flood current, and that in consequence the larvæ from hundreds of smaller streams and tributaries are carried away by the rising water and impelled into the current of the large streams, by which they may be carried for many miles, spreading out at last in the overflowed region at just the time when they are ready for their final transformations. On this theory the larvæ from regions far distant become massed in the overflowed region and vastly augment the numbers which have naturally bred there.

THE FALL WEB-WORM.

(*Hyphantria cunea*, Drury.)*

Order LEPIDOPTERA; family BOMBYCIDÆ.

[Plates X and XI.]

This insect has from time to time attracted general attention by its great injuries to both fruit and shade trees. Many authors have written about it, and consequently it has received quite a number of different names. The popular name "Fall Web-worm," first given to it by Harris, in his "Insects injurious to Vegetation," is sufficiently appropriate as indicating the season when the webs are most numerous. The term is, however, most expressive for the New England and other Northern States, where the insect is single-brooded, appearing there during August and September, while in more southern regions it is double-brooded. In our third Missouri report we first called attention to its double-broodedness at Saint Louis, and we find that it is invariably two-brooded at Baltimore and Washington. Except in seasons of extreme increase, however, the first brood does no wide-spread damage, while the Fall brood nearly always attracts attention.

We have decided to call attention to this insect somewhat in detail in this report because of its exceptional prevalence and injury in the Atlantic States during the year 1886, and because it became a public nuisance in the city of Washington, and the District Commissioners have formally requested information from us on the subject.

NATURAL HISTORY.

LIMITATION OF BROODS.—At Washington we may say in general that the first brood appears soon after the leaves have fully developed, and numerous webs can be found about the first of June, while the second brood appears from the middle of July on through August and September. In Massachusetts and other Northern States the first moths issue in June and July; the caterpillars hatch from the last of June until the middle of August, reach full growth and wander about seeking places for transformation from the end of August to the end of September.

The species invariably hibernates in the chrysalis state within its cocoon, and the issuing of the first brood of moths is, as a consequence, tolerably regular as to time, *i. e.*, they will be found issuing and flying slowly about during the evening, and more particularly

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*We have adopted the name *Hyphantria cunea*, following Clemens's reasons for separating *Hyphantria* from *Spilosoma*. He shows (Proc. Ac. Nat. Sci. Phil., 1860, p. 530) that, while agreeing in the wings, *Hyphantria* differs in the labial palpi, the second joint of which is very short and the terminal joint nearly rudimentary, and in the hind tibiæ, which have but one pair of small apical spurs.

The following is the synonymy of the species:

Phalæna (Bombyx) cunea Drury, 1782.
Phalæna punctatissima Abbott and Smith, 1797.
Cycnia cunea Huebner, 1821.
Spilosoma cunea (Drury), Westwood's Ed. Drury, 1837.
Hyphantria textor Harris, 1841.
Euproctis textor (Harris); Walker, 1855.
Hyphantria punctata Fitch, 1856.
Hyphantria textor Harris, Clemens, 1861.
Spilosoma cunea Drury, Brooklyn Soc. Check-list of Macro-Lep., 1882.
Hyphantria cunea (Drury), Grote's Check-list, 1882.

at night, during the whole month of May, the bulk of them early or late in the month, according as the season may be early or late. They couple and oviposit very soon after issuing, and in ordinary seasons we may safely count on the bulk of the eggs being laid by the end of May. During the month of June the moths become scarcer, and the bulk of them have perished by the middle of that month, while the webs of the caterpillars become more and more conspicuous. The second brood of moths begins to appear in July, and its occurrence extends over a longer period than is the case with the first or spring brood. The second brood of caterpillars may be found from the end of July to the end of September, hatching most extensively, however, about the first of August.

In Massachusetts and other Northern States the first moths issue in June and July; the caterpillars hatch from the last of June until the middle of August, reach full growth, and wander about seeking places for transformation from the end of August to the end of September.

The following general remarks upon the different stages refer to Washington and localities where the same conditions hold.

THE EGGS (Plate X, Fig. *3a*).—The female moth deposits her eggs in a cluster on a leaf, sometimes upon the upper and sometimes on the lower side, usually near the end of a branch. Each cluster consists of a great many eggs, which are deposited close together and sparsely interspersed with hair-like scales. In three instances those deposited by a single female were counted. The result was 394, 427, and 502, or an average of 441 eggs. But in addition to such large clusters each female will deposit eggs in smaller and less regular patches, so that at least 500 eggs may be considered as the real number produced by a single individual. The egg, measuring 0.4^{mm}, is of a bright golden-yellow color, quite globular, and ornamented by numerous regular pits, which give it under a magnifying lens the appearance of a beautiful golden thimble. As the eggs approach the time of hatching this color disappears and gives place to a dull, leaden hue.

The interval between the time of depositing and hatching of the eggs for the first brood varies considerably, and the latter may be greatly retarded by inclement weather. Usually, however, not more than ten days are consumed in maturing the embryo within. The eggs of the summer brood seldom require more than one week to hatch.

Without check the offspring of one female moth might in a single season (assuming one-half of her progeny to be female and barring all checks) number 125,000 caterpillars in early Fall—enough to ruin the shade trees of many a fine street.

THE LARVÆ (Plate X, Figs. *2a*, *2b*, and *2c*).—The caterpillars just born are pale yellow, with two rows of black marks along the body, a black head, and with quite sparse hairs. When full grown they generally appear pale yellowish or greenish, with a broad dusky stripe along the back and a yellow stripe along the sides; they are covered with whitish hairs, which spring from black and orange-yellow warts. The caterpillar is, however, very variable both as to depth of coloring and as to markings. Close observations have failed to show that different food produces changes in the coloration; in fact, nearly all the various color varieties may be found upon the same tree. The fall generation is, however, on the whole, darker, with browner hairs, than the spring generation.

As soon as the young caterpillars hatch they immediately go to work to spin a small silken web for themselves, which by their united efforts soon grows large enough to be noticed upon the trees. Under this protecting shelter they feed in company, at first devouring only the green upper portions of the leaf, and leaving the veins and lower skin unmolested. As they increase in size they enlarge their web by connecting it with the adjoining leaves and twigs; thus as they gradually work downwards their web becomes quite bulky, and, as it is filled with brown and skeletonized leaves and other discolored matter as well as with their old skins, it becomes quite an unpleasant feature in our public thoroughfares and parks. The caterpillars always feed underneath these webs; but as soon as they approach maturity, which requires about one month, they commence to scatter about, searching for suitable places in which to spin their cocoons. If very numerous upon the same tree the food-supply gives out, and they are forced by hunger to leave their sheltering homes before the usual time.

When the young caterpillars are forced to leave their web they do not drop suddenly to the ground, but suspend themselves by a fine silken thread, by means of which they easily recover the tree. Grown caterpillars, which measure 1.11 inches in length, do not spin such a thread. Both young and old ones drop themselves to the ground without spinning when disturbed or sorely pressed by hunger.

PUPA AND COCOON (Plate X, Figs. 2*d* and 2*e*).—Favorite recesses selected for pupation are the crevices in bark and similar shelters above ground, in some cases even the empty cocoons of other moths.* The angles of tree-boxes, the rubbish collected around the base of trees and other like shelter are employed for this purpose, while the second brood prefer to bury themselves just under the surface of the ground, provided that the earth be soft enough for that purpose. The cocoon itself is thin and almost transparent, and is composed of a slight web of silk intermixed with a few hairs, or mixed with sand if made in the soil.

The pupa is of a very dark-brown color, smooth and polished, and faintly punctuate. It is characterized by a swelling or bulging about the middle. It is 0.60 inch long and 0.23 inch broad in the middle of its body.

THE MOTH (Plate X, Figs. 1 *a–j*, and 2*f*).—The moths vary greatly, both in size and coloration. They have, in consequence of such variations, received many names, such as *cunea* Drury, *textor* Harr., *punctata* Fitch, *punctatissima* Smith. But there is no doubt, as proven from frequent breeding of specimens, that all these names apply to the very same insect, or at most to slight varieties, and that Drury's name *cunea*, having priority, must be used for the species.

The most frequent form observed in the vicinity of Washington is white, with a very slight fulvous shade. It has immaculate wings, tawny-yellow front thighs, and blackish feet. In some specimens the tawny thighs have a large black spot, while the shanks on the upper surface are rufous. In many all the thighs are tawny-yellow, while in others they have scarcely any color. Some specimens (often reared from the same lot of larvæ) have two tolerably distinct spots on each front wing, one at base of fork on the costal nerve and one just within the second furcation of the median nerve. Other specimens, again, have their wings spotted all over and approach the form *punctatissima*, described as the Many-spotted Ermine-moth of the Southern

* We have known the substantial cocoon of *Cerura* to be used for this purpose.

States. The wings of the moths expand from one inch and a quarter to one inch and three-eighths. The male moth, which is usually a little smaller, has its antennæ doubly feathered beneath, while those of the female possess instead two rows of minute teeth.

The pupa state lasts from six to eight days for the summer brood, while the hibernating brood, however, requires as many months, according to the latitude.

INJURY DONE IN 1886.

During the past year the city of Washington, as well as its vicinity, was entirely overrun by the caterpillars. With the exception of trees and plants the foliage of which was not agreeable to the taste of this insect, all vegetation suffered greatly. The appended list of trees, shrubs, and other plants shows that comparatively few kinds escaped entirely. The fine rows of shade trees which grace all the streets and avenues appeared leafless and covered with throngs of the hairy worms. Excepting on the very tall trees, in which the highest branches showed a few leaves too high for the caterpillars to reach, not a vestige of foliage could be seen. The trees were not alone bare, but were still more disfigured by old and new webs made by the caterpillars, in which bits of leaves and leaf-stems, as well as the dried frass, had collected, producing a very unpleasant sight. The pavements were also constantly covered with this unsightly frass, and the empty skins of the various molts the caterpillars had to undergo were drifted about with every wind and collected in masses in corners and tree-boxes. The parks fared a little better. Because of the great variety of trees planted there some escaped entirely, while others showed the effect of the united efforts of so many hungry caterpillars only in a more or less severe degree. The grassy spots surrounding the different groups of trees had also a protective influence, since the caterpillars do not like to travel over grass, except when prompted by a too ravenous hunger. The rapid increase of this insect is materially assisted by the peculiar method of selecting shade trees for the city. Every street has but one kind of shade tree; rows of them extend for miles, and the trees are planted so close together that their branches almost interlace. Thus there is no obstacle at all to the rapid increase and distribution of the caterpillars. If different kinds of trees had been planted so as to alternate, less trouble might be experienced. Plate XI shows a view of Fourteenth street, taken in late September, which illustrates the point, the Poplars on the west side being completely defoliated as far as the eye can reach, while the Maples on the east are almost untouched.

As long as the caterpillars were young and still small the different communities remained under cover of their webs and only offended the eye; but as soon as they reached maturity and commenced to scatter, prompted by the desire to find suitable places to spin their cocoons and transform to pupæ, matters became more unpleasant and complaints were heard from all those who had to pass such infested trees. In many localities no one could walk without stepping upon caterpillars; they dropped upon every one and every thing; they entered flower and vegetable gardens, porches and verandas, and the house itself, and became, in fact, a general nuisance.

The chief damage done to vegetation was confined to the city itself, although the caterpillars extended some distance into the surrounding country. There, however, they were more local and almost entirely

confined to certain trees, and mainly so to the White Poplar and the Cotton-wood. Along the Baltimore and Potomac Railroad tracks these trees were defoliated as far as five miles from the Capitol. In Georgetown the caterpillars were equally noxious, but in the adjoining forests but very few webs could be seen.

The proportionate injury to any given species of tree is to some extent a matter of chance; and in some respects a year of great injury, as 1886, is not a good year to study the preferences of a species, because when hard pressed for food the caterpillars will feed upon almost any plant, though it is questionable whether they can mature and transform on those which they take to only under the influence of such absolute necessity. Again, the preference shown for particular trees is more the result of the preference of the parent moth than of its progeny in a case of so general a feeder as the Fall Web-worm. We had a very good illustration of this in Atlantic City last autumn. The caterpillars were exceedingly abundant during autumn along this portion of the Atlantic coast, especially on the trees above named. We studied particularly their ways upon one tree that was totally defoliated by September 11. The bulk of the caterpillars were then just through their last molt, though others were of all ages, illustrating different hatchings. There was an instinctive migration of these larvæ of all sizes, and the strength of their food-habit once acquired from birth upon a particular tree was well illustrated. At first the worms passed over various adjacent plants, like Honeysuckles, Roses, &c., the leaves of which they freely devour if hatched upon them; but as the migrating swarm became pressed with hunger they finally fell upon these, and even upon plants like the Peach and Ailanthus, which ordinarily are passed over. They would even pounce upon any food, and a rotten apple placed in their way was soon literally swarming with them and sucked dry.

In a general way it may be stated that conifers, grapes, and most herbaceous plants are free from their attacks, and it is very doubtful whether the species can mature upon them.

The list of plants which follows is arranged according to the relative damage to the foliage in the city of Washington. The three first named are most subject to attack, and in fact are almost always defoliated.

PROPORTIONATE INJURY TO DIFFERENT PLANTS AND SHADE TREES.

The damage done in the city of Washington was exceptional, but so was also the general damage throughout the New England States, if not throughout the country. In New England the greater predilection which the species showed for Poplar, Cottonwood, and the ranker growing Willows was everywhere manifest, and so much was this the case, that the destruction of the first brood on these trees would have substantially lessened the damage to other trees.

Plants marked 1 have lost from 75 to 100 per cent. of their foliage.
Plants marked 2 have lost from 50 to 75 per cent. of their foliage.
Plants marked 3 have lost from 25 to 50 per cent. of their foliage.
Plants marked 4 have lost from 1 to 25 per cent. of their foliage.

Plants marked with two figures have shown the relative immunity or injury indicated by both, the variation being in individual trees.

1. *Negundo aceroides* Mœnch. (Box Elder.)
1. *Populus alba* L. (European White Poplar.)
1. *Populus monilifera* Ait. (Cottonwood.)

1–2. *Populus balsamifera* L. (Balsam Poplar.)
1–2. *Populus tremuloides* Mich'x. (American Aspen.)
1–2. *Fraxinus americana* L. (White Ash.)
1–2. *Fraxinus excelsior* L. (European Ash.)
1–2. *Sambucus canadensis* L. (Elder.)
1–2. *Pyrus* species. (Cultivated Pear and Apple.)
1–2. *Prunus avium* and *cerasus* L. (Cherries.)
1–4. *Syringa vulgaris* L. (Lilac.)
1–4. *Ilex* species. (Holly.)
2. *Platanus occidentalis* L. (Sycamore.)
2. *Salix* species. (Willow.)
2. *Tilia americana* L. (American Linden.)
2. *Tilia europæa* L. (European Linden.)
2. *Populus dilatata* Ait. (Lombardy Poplar.)
2. *Ulmus americana* L. (American White Elm.)
2–3. *Ulmus fulva* Mich'x. (Slippery Elm.)
2–3. *Prunus armenica* L. (Apricot.)
2–3. *Alnus maritima* Muhl. (Alder.)
2–3. *Betula alba* L. (White Birch.)
2–3. *Viburnum* species. (Haw or Sloe.)
2–3. *Lonicera* species. (Honeysuckles.)
2–3. *Prunus americana* Marsh. (Wild Red Plum.)
2–3. *Celtis occidentalis* L. (Hackberry.)
2–3. *Rosa* species. (Rose.)
2–3. *Gossypium album* Ham. (Cotton.)
2–3. *Cephalanthus occidentalis* L. (Button Bush.)
2–3. *Vitis* species. (Grape-vine.)
2–4. *Convolvulus* species. (Morning Glory.)
2–4. *Acer saccharinum* Wang. (Sugar Maple.)
2–4. *Geranium* species. (Geranium.)
3. *Betula nigra* L. (Red Birch.)
3. *Tecoma radicans* Juss. (Trumpet Creeper.)
3. *Symphoricarpus racemosus* Mich'x. (Snowberry.)
3. *Larix europæa* Del. (European Larch.)
3. *Corylus americana* Walt. (Hazel-nut.)
3. *Quercus alba* L. (White Oak.)
3. *Diospyros virginiana* L. (Persimmon.)
3. *Carya* species. (Hickory.)
3. *Juglans* species. (Walnut.)
3. *Wistaria sinensis* Del. (Chinese Wisteria.)
3. *Wistaria frutescens.* (Native Wisteria.)
3. *Amelanchier canadensis* T. and G. (Shad-bush.)
3. *Cratægus* species. (Haw.)
3. *Rubus* species. (Blackberry.)
3. *Spiræa* species. (Spiræa.)
3. *Ribes* species. (Currant and Gooseberry.)
3. *Staphylea trifolia* L. (Bladder Nut.)
3–4. *Cydonia vulgaris* Pers. (Quince.)
3–4. *Asimina triloba* Dun. (Pawpaw.)
3–4. *Berberis canadensis* Pursh. (Barberry.)
3–4. *Catalpa bignonioides* Walt. (Indian Bean.)
3–4. *Catalpa speciosa* Ward. (Bignonia.)
3–4. *Euonymus atropurpureus* Jaeg. (Burning Bush.)
3–4. *Cupressus thyoides* L. (White Cedar.)
3–4. *Juniperus virginiana* L. (Red Cedar.)
3–4 *Cornus florida* L. (Flowering Dogwood).

3–4. *Cornus alternifolia* L. (Alternate-leaved Dogwood.)
3–4. *Carpinus americana* Mich'x. (Hornbeam.)
3–4. *Castanea americana* Mich'x. (American Chestnut.)
3–4. *Castanea pumila* Mich'x. (Chinquapin.)
3–4. *Ostrya virginica* Willd. (Hop Hornbeam.)
3–4. *Quercus coccinea* Wang. (Scarlet Oak.)
3–4. *Quercus phellos* L. (Willow Oak.)
3–4. *Quercus prinus* L. (Chestnut Oak.)
3–4. *Quercus rubra* L. (Red Oak.)
3–4. *Diospyros kaki* L. (Japan Persimmon.)
3–4. *Buxus sempervirens* L. (Common Box.)
3–4. *Hamamelis virginica* L. (Witch Hazel.)
3–4. *Sassafras officinale* Nees. (Sassafras.)
3–4. *Cercis canadensis* L. (Red Bud.)
3–4. *Hibiscus syriacus* L. (Tree Hibiscus.)
3–4. *Rhamnus alnifolius* L'Her. (Alder-leaved Buckthorn.)
3–4. *Prunus virginiana* L. (Choke Cherry.)
3–4. *Persica vulgaris* Millan. (Peach.)
3–4. *Æsculus hippocastanum* L. (Horse Chestnut.)
3–4. *Paulownia imperialis* Seeb. (Cigar-tree.)
3–4. *Ailanthus glandulosus* Daf. (Tree of Heaven.)
3–4. *Maclura aurantiaca* Nutt. (Osage Orange.)
3–4. *Ampelopsis quinquefolia* Mich'x. (Virginia Creeper.)
3–4. *Clematis* species. (Clematis.)
3–4. *Trifolium* species. (Clover.)
3–4. *Helianthus* species. (Sunflower.)
3–4. *Jasminum* species. (Jessamine).
3–4. *Ficus carica* L. (Fig.)
4. *Rhus cotinus* L. (Smoke Tree.)
4. *Pinus* species. (Pine.)
4. *Taxus* species. (Yew.)
4. *Nyssa multiflora*, Wangerh. (Sour Gum.)
4. *Fagus ferruginea* Ait. (Beech.)
4. *Kalmia* species. (Laurel.)
4. *Rhododendron* species. (Rhododendron.)
4. *Ricinus communis* L. (Castor-oil Plant.)
4. *Liquidambar styraciflua* L. (Sweet Gum.)
4. *Gleditschia triacanthos* L. (Honey Locust.)
4. *Gymnocladus canadensis*, Lamb. (Kentucky Coffee Tree.)
4. *Robinia pseudacacia* L. (Locust.)
4. *Liriodendron tulipifera* L. (Tulip Tree.)
4. *Magnolia* species. (Magnolia.)
4. *Chionanthus virginicus* L. (Fringe Tree.)
4. *Ligustrum vulgare* L. (Privet.)
4. *Zanthoxylum americanum* M. (Prickly Ash.)
4. *Acer dasycarpum* Ehrh. (White or Silver Maple.)
4. *Acer rubrum* Wangert. (Red Maple.)
4. *Æsculus flava*, Ait. (Sweet Buckeye.)
4. *Æsculus glabra* Willd. (Ohio Buckeye.)
4. *Morus rubra* L. (Red Mulberry.)

Trees in the vicinity of the White Poplar and Cottonwood suffer most. Even trees usually not injured, as, for instance, the Sugar Maple, are often badly defoliated when in such contiguity.

This list contains a number of plants not usually injured by these caterpillars. In some cases the injury was due to the fact that twigs containing the web with its occupants had been pruned from the tree

and thrown near plants, instead of being burned at once or otherwise destroyed.

In other cases the injury is due to the peculiar position of the plant injured, *i. e.* under a tree infested by the caterpillars. These, when fully grown, commence to scatter, and dropping upon the plant underneath the tree, soon defoliated it without actually making their home upon it. The great number thus dropping from a large tree will soon defoliate any smaller plant, even if each caterpillar takes but a mouthful by way of trial. Thus Holly, a plant not usually eaten by these insects, soon became denuded. Other plants, unpalatable or even obnoxious to the caterpillars, are sometimes destroyed by the multitudes in their search for more suitable food.

Hungry caterpillars, leaving a denuded tree in search of food, wander in a straight line to the next tree, sometimes a distance of 25 feet, showing that they possess some keen sense to guide them. If such a tree offers unsuitable food, they still explore it for a long time before deserting it. In this manner two columns of wandering caterpillars are formed, which frequently move in opposite directions.

PECULIAR EFFECT OF DEFOLIATION UPON SOME PLANTS.

During the early part of October many trees, mainly Apple and Pear, which had been entirely denuded of their foliage by the caterpillars, showed renewed activity of growth. Some had a few scattered flowers upon them, others had one or two branches clothed with flowers, while in some few cases the whole tree appeared white. It looked as if the trees were covered with snow, since they lacked the green foliage usually seen with blossoms in spring. Some few flowers were also observed upon badly defoliated Cherry trees. Even as late as the middle of November, owing perhaps also to the pleasantly warm weather, some few flowers could be observed upon some imported plants belonging to the genus *Spiræa* and upon the Chinese Red Apple. All these plants usually flower early in spring. The caterpillars, having entirely defoliated the tree, produced thus an artificial period of rest, or winter, which was followed by unseasonable budding and flowering. Such a result often follows summer denudation by any insect, and we have referred to some remarkable cases in our previous writings.*

ENEMIES OF THE WEB-WORM OTHER THAN INSECTS.

The caterpillars have comparatively few enemies belonging to the vertebrate animals. This is not owing to any offensive odor or to any other means of defense, but it is entirely due to their hairiness. Chickens, and even the omnivorous ducks, do not eat them; if offered to the former they pick at these morsels, but do not swallow them.

The English Sparrow has, in this case at least, not proven of any assistance whatever. Indeed, as before stated, its introduction and multiplication have greatly favored the increase of the worms.

The "pellets" of a Screech-owl (*Scops asio*), found in the vicinity of Baltimore, Md., and examined by Mr. Lugger, consisted apparently almost entirely of the hairs of these caterpillars, proving that this useful bird had done good service.

Perhaps the statement may be of interest, that this little owl is

*See Eighth Report on the Insects of Missouri, p. 121.

getting much more common in the vicinity of such cities in which the English Sparrows have become numerous, and that the imported birds will find in this owl as bold an enemy as the Sparrow-hawk is to them in Europe, and even more dangerous, since its attacks are made towards dusk, at a time when the Sparrow has retired for the night, and is not as wide awake for ways and means to escape.

If our two Cuckoos, the Black-billed as well as the Yellow-billed species, could be induced to build their nests within the city limits or in our parks, we should gain in them two very useful friends, since they feed upon hairy caterpillars.

The common Toad (*Bufo americana*) has eaten great numbers of these caterpillars, as shown by dissections made by Mr. Lugger, and it should be carefully protected, instead of being tormented or killed by boys, or even grown people. The Toad is always a useful animal, and ought to be introduced in all gardens and parks.

The following species of spiders were observed to eat the caterpillars, viz, *Marpessa undata* Koch, and *Attus* (*Phydippus*) *tripunctatus*. Neither species builds a web, but obtains its prey by boldly leaping upon it; they are, in consequence of such habits, frequently called tiger spiders. The former was exceedingly common last year, more so than for many previous years, thus plainly indicating that the species did not suffer for lack of food. This species is usually found upon the trunks of trees, and is there well protected by its color, which is like that of the bark. It hides in depressions and cracks of the bark, and, jumping upon the passing game, or, catlike approaching it from behind, it thrusts its poisonous fangs into the victim, which soon dies and is sucked dry. The *Attus* has similar habits, but is still more cautious; it usually hides under loose bark. Both spiders are wonderfully active and kill large numbers of caterpillars. Their large and flat egg-masses can be found during the winter under dead bark and in cracks. Both species hibernate in silken nests in similar localities.

PREDACEOUS INSECT ENEMIES.

The caterpillars of this moth have quite a number of external enemies, which slay large numbers of them. The well-known Rearhorse (*Mantis carolina*) seems to be very fond of the caterpillars. The so-called Wheel-bug (*Prionidus cristatus*) has proved to be one of our best friends in reducing the numbers of the caterpillars. This insect was formerly by no means very common in cities, but of late years it has greatly increased in numbers, and is now a well-known feature in all our public parks and such streets as possess shade trees. Outside of the city it is rarely met with; nor does it extend much farther North than Washington. It is, like the Mantis, in all its stages a voracious feeder upon insects, slaying alike beneficial and noxious ones. The bright-red larvæ and pupæ, also carnivorous, are seen in numbers during the summer; they usually remain together until hunger forces them to scatter. They assist each other in killing larger game, and are to this extent social. The Wheel-bug could be observed almost anywhere last summer, but usually motionless, stationed upon the trunks of trees, waiting for the approach of an insect. If one comes near, it quite leisurely inserts its very poisonous beak and sucks the life-blood of its victim. When this becomes empty it is hoisted up in the air, as if to facilitate the flow of blood, until eventually it is thrown away as a mere shriveled skin. The

appetite of the Wheel-bug is remarkable, whenever chances offer to appease it to the fullest extent. Frequently, however, times go hard with it, and notwithstanding it is very loath to change a position once taken, it is sometimes forced to seek better hunting-grounds, and takes to its wings. The Wheel-bug has been observed to remain for days in the same ill-chosen position—for instance upon the walls of a building—waiting patiently for something to turn up. It is slow in all its motions, but withal very observant of everything occurring in its neighborhood, proving without doubt great acuteness of senses. It does not seem to possess any enemies itself, and a glance at its armor will indicate the reason for this unusual exemption.* During warm weather this bug possesses a good deal of very searching curiosity, and a thrust with its beak filled with poison is very painful indeed. Boys call it the "blood-sucker," a misnomer, since it does not suck human blood. Its eggs are laid during the autumn in various places, but chiefly upon smooth surfaces of the bark of tree trunks, and frequently in such a position as to be somewhat protected against rain by a projecting branch. The female bug always selects places the color of which is like that of the eggs, so that they are not easy to see, notwithstanding their large size.

Euschistus servus Say is another hemipterous insect that preys upon the caterpillar of *H. textor*, and in a similar manner to the Wheel-bug. It is a much smaller, but also a very useful insect.

Podisus spinosus, Dall., in all its stages, was quite numerous during the caterpillar plague. Its brightly-colored larvæ and pupæ were usually found in small numbers together, but as they grew older they became more solitary in their habits. All stages of this insect frequent the trunks and branches of trees, and are here actively engaged in feeding upon various insects. As soon as one of the more mature larvæ or pupæ has impaled its prey the smaller ones crowd about to obtain their share. But the lucky captor is by no means willing to divide with the others, and he will frequently project his beak forward, thus elevating the caterpillar into the air away from the others. The habit of carrying their food in such a difficult position has perhaps been acquired simply to prevent others from sharing it. A wonderful strength is necessary to perform such a feat, since the caterpillar is sometimes many times as heavy as the bug itself. The greediness of this bug was well illustrated in the following observation: A pupa of *P. spinosus* had impaled a caterpillar, and was actively engaged in sucking it dry; meanwhile a Wheel-bug utilized a favorable opportunity and impaled the pupa without forcing the same to let go the caterpillar. The elasticity of the beak of these bugs must be very great; they can bend it in any direction and yet keep it in sucking operation. The poison contained in the beak must act very rapidly, since the caterpillars impaled by it squirm but a very short time and then become quiet.

FUNGUS DISEASE OF THE WEB-WORM.

In our Fourth Missouri Entomological Report, p. 88, we called attention to the fact that the fungus disease of the domestic Silk-worm, called in France *Muscardine*, and supposed to be due to the development in the worms of the fungus *Botrytis bassiana*, or a disease which had not yet been distinguished from it, had made its appearance

*Its eggs, however, are pierced by a little egg-parasite—*Eupelmus reduvii* Howard.

among Silk-worms, both imported and wild, in some of the Eastern States, and that in the fall of 1870 it was so common around Saint Louis that we found hundreds of hairy caterpillars stiffly fastened to their food-plants and covered with the white efflorescence. On several occasions in Saint Louis we found the *Hyphantria* larvæ generally affected by it.

The latest authority upon this fungus (Saccardo) gives it as living upon Bombycid larvæ, particularly upon the Silk-worm of commerce, in France, Italy, and North America. *Botrytis tenella*, which he described in his "*Fungi Italicæ*" as a new species, he now considers as only a variety of *B. bassiana*. This variety is found upon dipterous larvæ and pupæ, upon wasps of the genus *Vespa*, and upon the larvæ of the coleopterous genus *Melolontha*. (P. A. Saccardo, *Sylloge Hyphomycetum omnium huscusque cognitorum*, Vol. IV, p. 119, Patavia, 1886.)

The first brood of the Web-worms at Washington in 1886 showed in some quite well-defined localities the indications of a fungus disease, which was probably only a variety of this *Botrytis*. It did not become, however, so general as later in the season, when it prevailed everywhere; yet it could be observed that the contagion had started from certain points. In such localities almost all the caterpillars were diseased and died, and large numbers of the dead were huddled together as in life. But when investigated their bodies were hard and dry, and would readily crumble to pieces when pressed, producing an odor like that of some mushrooms. Only full-grown, or rather caterpillars in their last larval skin, were thus affected. The dry remains had retained the original shape, and, if killed but recently by the fungus, their color as well. Before dying the caterpillars had fastened themselves very securely to trunks, twigs, and leaves of various trees, somewhat like the common house-fly, that dies by a similar disease in large numbers during September in our houses and produces around itself such a characteristic halo of white spores. Caterpillars infested by the incipient stages of this disease wander about aimlessly and at an irregular speed; often they halt for some time, then squirm about frantically to start again, and frequently in an opposite direction to the one they were going before. If such a diseased caterpillar is confined to a glass jar and observed, it is soon seen that a white mealy substance gradually grows out of all the soft spaces between the segments, which eventually covers the whole insect, leaving generally only the black head and tips of hairs visible. Before long many spores are scattered about, forming a circle of white dust around the caterpillar, and, if not arrested by an obstruction in its expulsion, the halo thus formed is quite regular and about 2 inches in diameter. Outdoors this white dust is but seldom observed, because even the slightest draft of air will carry it away and drift it about. Even the white mealy substance adhering to the caterpillar itself is usually swept away, and the victims look very much like healthy caterpillars; but they darken with time, and eventually drop to the ground. The magnifying-glass, however, still reveals some spores adhering to the hairs upon the under side and upon the bark or leaf of the tree in the immediate neighborhood.

This fungus kills caterpillars even after they have made their cocoons. Nor does the pupa escape. In the latter case the spores form a white crest over every suture of the thoracic segments; the abdominal segments, however, remain free from it. Evidently the caterpillars were nearly full-grown when attacked by the disease,

and possessed vigor enough to transform into pupæ; later the fungus grew, and pressing the chitinous portion of the pupa apart, forced itself to the air to fructify.

Plants not usually eaten by the caterpillars, as well as others not eaten at all, have upon them the largest numbers of caterpillars killed by the fungus, provided that they grew in the vicinity of suitable food-plants. Perhaps unsuitable food, predisposing the caterpillars for any disease, is one of the causes of the innumerable host killed by this fungus.

The white cocoons of a parasite (*Apanteles hyphantriæ*) were in some cases observed to be covered with similar fungus spores. Opening such cocoons it was seen that the spores were not simply blown upon the silk and there retained, but that they came from the victim within, and had forced their way through the very dense silken mass.

EXPERIMENTS TO OBTAIN PERCENTAGE OF DISEASED CATERPILLARS.

Experiment I:

One hundred and twenty-five nearly grown caterpillars were gathered (October 7, 1886) at random in one of our public parks. They were imprisoned in large glass jars, and daily supplied with suitable food.

Result, October 18, 1886:

11 apparently healthy pupæ.
3 deformed pupæ.
18 yellow cocoons of *Meteorus hyphantriæ*.
9 dead pupæ, killed by fungus or otherwise.
84 dead caterpillars, killed by fungus or otherwise.

125

In the earth of the jar were found 17 pupæ of Tachina flies, leaving 67 caterpillars and 9 pupæ killed by the fungus, or 61 per cent.

Experiment II:

One hundred and twenty-five nearly grown caterpillars were gathered (October 7, 1886) from a trunk of a soft maple (unsuitable food) and treated as above.

Result, October 18, 1886:

8 apparently healthy pupæ.
1 deformed pupa.
7 yellow cocoons of *Meteorus hyphantriæ*.
3 dead pupæ, killed by fungus or otherwise.
104 dead caterpillars, killed by fungus or otherwise.
2 cocoons containing Tachina larvæ.

125

In the earth of the jar were found 28 pupæ of Tachina flies, leaving 76 caterpillars and 3 pupæ killed by fungus, or 63 per cent.

In both experiments it has been assumed that each Tachina fly had killed one caterpillar.

On November 15, 1886, the jars were again investigated and it was found that a number of the pupæ had been killed by the fungus since October 18, 1886, and that in fact all the remaining ones appeared diseased. The percentage of death by the fungus in the two experiments was thus increased to 63 per cent. in Experiment I and to 67 per cent in Experiment II.

TRUE PARASITES OF THE WEB-WORM.

Up to the present time no parasites of this insect have ever been recorded. On August 18, 1883, we bred a number of egg-parasites from a batch of eggs found upon a willow leaf at Washington, but unfortunately no description was made of them at the time, and, as they belonged to the soft-bodied genus *Trichogramma*, the specimens have now become so much shriveled and altered that they are unfit for descriptive purposes. We noticed after our return from Europe in September of this year that, at a number of points in New England, the worms were quite commonly attacked by parasites, and careful investigation at Washington by Mr. Lugger showed the presence of no less than five distinct species of primary parasites in addition to the *Trichogramma* just mentioned. These will be considered in some detail. The first was a new egg-parasite, which we have named *Telenomus bifidus;* the others were all parasitic on the larvæ, and consisted of a Braconid (*Meteorus hyphantriæ* n. sp.); a Microgaster (*Apanteles hyphantriæ*, n. sp.); an Ophionid (*Limneria pallipes* Prov.), and a Tachinid, which, though probably new, we shall not attempt to describe. These last four have been mentioned in about the order of their relative abundance and consequent importance. An astonishing number of Web-worms were killed by the four parasites, and so many died from this cause and from the fungus disease previously mentioned as to fully warrant the prediction of almost complete immunity for the summer of 1887.

In addition to these parasites found last Fall, the note-books of the Division show a prior breeding of another primary parasite, which will not be treated in detail here on account of insufficient material. It is an external feeder on the larva and belongs to the genus *Euplectrus*. It is closely related to *E. platyhypenæ*, described by Mr. Howard in Bulletin 5 of this Division.

We have found, however, that three of these primary parasites of the Web-worm, viz, the *Apanteles*, the *Limneria*, and the *Meteorus*, were killed off at a serious rate late in the season by secondary parasites, most of which belong to the family *Chalcididæ* with the exception of three species of the Ichneumonid genus *Hemiteles*. So extensive has been this killing off of the primary parasites by the secondary, that were not the fates of the three classes, viz, the plant-feeder, the primary and the secondary parasites so interwoven, the destruction of these beneficial insects might be considered a serious matter in dealing with the plant-feeder.

We have not taken time to determine these secondary parasites specifically, but give a little table showing the number of species concerned, mentioning them only by their genera:

SECONDARY PARASITES.

On *Apanteles:*

1. *Hemiteles* sp.
2. *Elasmus* sp.
3. *Eupelmus* sp.
4. *Panstenon* sp.
5. *Cirrospilus* sp
6. *Pteromalus* sp.
7. *Pteromalus* sp.

On *Meteorus hyphantriæ*:
1. *Hemiteles* sp. (= 1 on *Apanteles*).
2. *Spilochalcis* sp.
3. *Hemiteles utilis* Nort.
4. *Eupelmus* sp. (= 3 on *Apanteles*).
5. *Hemiteles* sp.
6. *Pteromalus* sp. (= 6 on *Apanteles*).
7. *Pteromalus* sp. (= 7 on *Apanteles*).

On *Limneria pallipes* Prov.:
1. *Eupelmus* sp. (= 3 on *Apanteles*).
2. *Tetrastichus* sp.
3. *Pteromalus* sp. (= 6 on *Apanteles*).
4. *Pteromalus* sp. (= 7 on *Apanteles*).
5. *Elasmus* sp. (= 2 on *Apanteles*).

THE TELENOMUS EGG-PARASITE.—A single egg of *H. cunea* is a very small affair, yet it is large enough to be a world for this little parasite, which undergoes all its transformations within it, and finds there all the food and lodgment required for the short period of its life. In several instances batches of eggs of this moth were parasitized, and instead of producing young caterpillars they brought forth the tiny insects of this species. The batches of parasitized eggs were found July 27 upon the leaves of Sunflower. Judging from this date, it was the second brood of moths which had deposited them. There can be no doubt, however, that eggs produced by moths emerging from their cocoons in early spring had been parasitized as well. The female *Telenomus* was also observed August 2, busily engaged in forcing its ovipositor into the eggs and ovipositing therein. The female insect is so very intent upon its work that it is not easily disturbed, and one can pluck a leaf and apply a lens without scaring it away. The eggs soon hatch inside the large egg of the moth, and the larvæ produced soon consume the contents. This egg-parasite is a very useful friend, nipping the evil in the bud, so to speak.

This parasite is new, and may be characterized as follows:

TELENOMUS BIFIDUS n. sp. ♂ ♀.—Average length, 0.75^{mm}; average expanse, 1.7^{mm}. Color of body, black throughout. *Head* three times as broad as long when seen from above; face, especially in the middle, lustrous and without sculpture; vertex polished and without a carina behind lateral ocelli; antennæ black, except bulla, which is honey-yellow, 11-jointed, joints 2 and 3 subequal in length. *Thorax:* Mesonotum very delicately punctulate and furnished with a moderately dense, fine, whitish pile; no parapsidal sutures; legs yellow, except coxæ, femora, and last joints of all tarsi, which are black or blackish; tibial spur of front legs bifid when seen under a high power, and corresponding first tarsal joint furnished with a fine and strong comb of bristles; fore wings with 11 costal bristles and with 3 cells visible in stigmal club. *Abdomen* with the second segment striate only at base.

Described from 5♀, 2♂, bred July 27, 1886, from eggs of *Hyphantria cunea* collected in the District of Columbia.

This species belongs nearest to *T. phalænarum* Nees, of Europe, which has been bred from the eggs of *Porthesia chrysorrhea* by Wachtl, from eggs of *Panolis piniperda* by Nördlinger, and from eggs of an unknown Noctuid on the leaves of *Æsculus hippocastanum* by Mayr. (See Mayr, "*Ueber die Schlupfwespengattung Telenomus*" Verh. d. k.-k. zoöl. Ges., Wien, 1879, p. 709.)

THE METEORUS PARASITE OF THE WEB-WORM (Plate X, fig. 4.)—This parasite has performed very good service during the caterpillar plague, and has done much to check any further increase of the Web-

worm. During the earlier part of the summer this insect was not very numerous, but sufficient proofs in form of empty cocoons were observed to indicate at least one earlier brood. Towards the end of September, and as late as the 15th of October, very numerous cocoons of a second brood were formed; they could be found in all situations to which the caterpillar itself had access. But the great majority of them were suspended from the trunks* and branches of trees, and chiefly from near the base of the trunk. Each represents the death of one nearly full-grown caterpillar, since the latter harbors but one larva of the parasite. A careful watch was kept to see how such a suspended cocoon was formed, but in vain. Once a larva had just started to make a cocoon, but became detached, and dropped out of the orifice and commenced a new one. The larva, suspended by the mandibles, evidently spins at first loose, irregular, horizontal loops around its body, until a loose cradle is formed. The silk secreted for this purpose hardens very rapidly when exposed to the air. When secure inside this cradle it lets go its hold with the mandibles, and finishes the soft inside cocoon in the usual manner. If the larva has dropped to the ground, it still makes an outer loose cocoon, but the silken threads are thicker and much more irregular. In cocoons made during a high wind, the threads that suspend them are much longer, reaching sometimes the length of 4 inches; the more normal length varies from $1\frac{1}{2}$ to 2 inches.

To find out the length of time which this insect occupies in maturing inside the cocoon 44 freshly made cocoons were put in a glass jar. With remarkable regularity, but ten days were consumed by the insect in changing from the larval to the winged form. The winged *Meteorus* issues through a perfectly round hole at the lower end of the cocoon by gnawing off and detaching a snugly fitting cap. The several secondary parasites of the *Meteorus* which we have mentioned all leave the cocoon of their host by smaller holes cut through the sides. Most of the adult *Meteorus* had issued by the 1st of November; but it is possible that some may remain in their cocoons until spring.

In order to obtain the proportion between the *Meteorus* raised from cocoons and its parasites (*i. e.*, secondary parasites of *Hyphantria*), 450 cocoons were confined in a glass jar the latter part of September Up to the first week in November only 70 specimens were bred from these cocoons, the rest giving out secondary parasites, which continued to issue up to date of writing (December 20, 1886). Thus only 16 per cent. of the cocoons produced the primary, while 84 per cent. produced secondary parasites. The insect is new, and we submit the following description:—

METEORUS HYPHANTRIÆ n. sp.—♀. Length, 5^{mm}; expanse, 11^{mm}. Comes nearest to *Meteorus communis* Cress., being, however, a larger species. Its cocoons are also larger and of a darker yellow-brown in color. General color, honey-yellow. The irregular reticulation of the metanotum shows less tendency to arrange itself in longitudinal carinæ, particularly into one median and two sublateral. The fine longitudinal impressed aciculations of the first abdominal segment are nearly parallel in *hyphantriæ*, while in *communis* the middle ones converge strongly towards the center behind. The general color is, as in *communis*, yellowish-ferruginous or honey-yellow. In general, *hyphantriæ* has more dark markings than *communis*. The antennæ are dusky at tip; the mandibles are brown at tip; the mesoscutum has two nearly black patches at sides and often a dusky stripe down middle; the metanotum is usually entirely dark, as is also the first joint of the abdomen above; the rest of the abdomen has two larger or smaller dark spots on each side; the sheaths of the

* In one instance only, the cocoon of this parasite was found inside that of its host.

ovipositor are dark, especially at base, and the ovipositor itself is honey-yellow; the legs are all honey-yellow except the tips of the hind tibiæ, which are dark.

♂.—Resembles the female, with the usual structural differences. Varies considerably in color, some specimens being almost immaculate, while others are marked like the female. Wing venation in both sexes varies in no way from that of *communis*, and but slightly from that in other species of the genus; in that the second submarginal cell is subquadrate, broadening slightly posteriorly, and in the first transverse cubital nervure being confluent with the recurrent nervure.

Described from 18♀, 9♂ specimens, all bred in District of Columbia from cocoons collected near remains of larvæ of *Hyphantria cunea*.

THE MICROGASTER PARASITE OF THE WEB-WORM.—This insect was about as numerous as the *Meteorus*, and did equally good service in preventing a further increase of the caterpillars. It appeared somewhat earlier in the season, and had killed only half-grown caterpillars. From the numerous old and empty cocoons in early summer it was plainly seen that a first brood had been quite numerous, and that from these cocoons mainly *Apanteles* had been bred, and not, as during the autumn, mostly secondary parasites. The white silky cocoon is formed almost under the middle of a half-grown caterpillar, and is fastened securely to the object its host happened to rest upon, and but slightly to the host itself, which is readily carried to the ground by wind and rain, and can therefore only be in position in the more sheltered places, such as cracks and fissures of the bark of trees. But one *Apanteles* is found in a caterpillar, so that each white cocoon indicates, like a tombstone, the death of a victim. In some places, and notably upon the trunks of poplars, these cocoons were so numerous as to attract attention; it seemed as if the trunk had been sprinkled with whitewash. But notwithstanding such vast numbers, but two specimens of the architects of these neat cocoons were raised; all the rest had been parasitized by secondary parasites. It is barely possible, however, that some specimens may hibernate in their cocoons, since numbers of them have as yet (December 20, 1886) not revealed any insects. The winged *Apanteles* leaves the cocoon by a perfectly round orifice in the front, by cutting off a little lid, which falls to the ground. Its parasites, however, leave by small holes cut through the sides. These secondary parasites were very common late in September and early in October, and busily engaged in inserting their ovipositors through the tough cocoon into their victim within. It seems as if the cocoons formed early in the season were on an average a little smaller than those formed later.

The cocoons of this *Apanteles* are of a uniform white color, but exceptionally a distinctly yellowish cocoon is found. From these yellow cocoons nothing has so far been bred, but since, as we have elsewhere shown,* the color of the cocoon may vary in the same species, it is probable that the variation here referred to is not specific.

Not quite one-half of 1 per cent of these cocoons produced the insect belonging to it; 99 per cent produced secondary parasites.

APANTELES HYPHANTRIÆ, n. sp.—♀. Length, 3^{mm}. Close to *Apanteles xylina*, Say, with which it may be compared. Differs as follows: Mesonotum without the faint median carina or polished posterior margin; scutellum not polished; first abdominal segment about as broad as long, with a quite distinct median carina, the apex of which is polished, and its posterior margin broadly bilobed. In *A. xylina* the first abdominal segment is rather slender, and longer than wide, without distinct carina and with the apex almost straight. A quite distinct carina on the second segment, wanting in *xylina*. Third abdominal segment coarsely pitted at base,

* Notes on North American Microgasters, &c., Trans. Saint Louis Acad. Sciences, vol. 4, author's separate copy, p. 7.

the rest quite distinctly shagreened; in *xylina* the basal punctuation is less pronounced and the rest of the segment smooth. All coxæ black (in *xylina* the apical half of lower edge of posterior coxæ is reddish); the first joint of metatarsi perceptibly stouter than the other joints (almost like the other joints in *xylina*). Cocoon white and single (in *xylina* the cocoons are enclosed in wooly masses).

Described from two ♀ specimens.

THE LIMNERIA PARASITE OF THE WEB-WORM.—In addition to the two Hymenopterous parasites treated of, a third one has been very numerous, and has done much good in reducing the numbers of caterpillars. This, an Ichneumonid, and a much larger insect, does not form an exposed cocoon like that of the other parasites described. Yet a little attention will soon reveal large numbers of them. Upon the trunks of various trees, but chiefly upon those of the Poplar and Sugar Maple, small colonies of caterpillars, varying in number from 4 to 12, could be observed, which did not show any signs of life. When removed from the tree they appeared contracted, all of the same size, and pale or almost white. A closer inspection would reveal the fact that the posterior portion of the caterpillar had shrunken away to almost nothing, whilst the rest was somewhat inflated, and covered with an unchanged, but bleached skin, retaining all the hairs in their normal position. Opening one of these inflated skins, a long, cylindrical, brown cocoon would be exposed; this is the cocoon of the *Limneria* under consideration. As numbers of such inflated skins would always occur together, it was clearly seen that the same parent *Limneria* had oviposited in all of them. Most of the cocoons were found in depressions of the rough bark, or other protected places. Single ones were but rarely met with. The Hyphantria larvæ in dying had very securely fastened all their legs into the crevices of the bark, so that neither wind nor rain could easily dislodge them. Only half-grown caterpillars had thus been killed. Many of these inflated skins showed in the early part of October a large hole of exit in their posterior and dorsal ends, from which the Ichneumons had escaped. Trying to obtain winged specimens of this parasite, 140 of these cocoons—and only such as were not perforated in any way—were collected and put in a glass jar. Only a single female was produced from all up to time of writing, whilst very large numbers of secondary parasites issued from October 11 to November 20, and doubtless others will appear during the spring of 1887, because some of these inflated skins show as yet no holes of exit.

This parasite is, according to Mr. Cresson, unnamed in the Philadelphia collection, and, after close study of all accessible descriptions, we have decided that it should be placed, temporarily at least, with Provancher's *Limneria pallipes*. The specimens which we have bred correspond with his variety, in which the four anterior femora are pale red. The species is not unlike *L. lophyri* Riley, which we described in our Ninth Missouri Entomological Report from a large series of specimens bred from the larvæ of Abbott's White Pine Worm (*Lophyrus abbottii*), but is smaller and has certain colorational differences.

THE TACHINA PARASITE OF THE WEB-WORM.—The parasites of *H. textor* described so far belong to the order *Hymenoptera*, which furnishes the greatest number of them; but the fly now to be treated is fully as useful as any of the others. We have not named and described this species, on account of the fact that the family to which

it belongs has not been worked up and because the characters are not well understood.

Tachina flies are very easily overlooked, because they resemble large house-flies both in appearance and flight, and their presence out of doors is not usually noticed on that account. Yet they play a very important rôle, living as they do in their larval state entirely in insects. During the caterpillar plague such flies were often seen to dart repeatedly at an intended victim, buzz about it, and quickly disappear. If the caterpillar thus attacked was investigated, from 1 to 4 yellowish-white, ovoid, polished, and tough eggs would be found usually fastened upon its neck, or on some spot where they could not readily be removed. These eggs are glued so tightly to the skin of the caterpillar that they cannot easily be removed. Sometimes as many as 7 eggs could be counted upon a single caterpillar, showing a faulty instinct of the fly or flies, because the victim is not large enough to furnish food for so many voracious maggots. If the victim happens to be near a molt, it casts its skin with the eggs, and escapes a slow but sure death. But usually the eggs hatch so soon, that the small maggots have time to enter the body of the caterpillar, where they soon reach their full growth, after which they force their way through the skin and drop to the ground, into which they enter, to shrink into a brown, tunlike object (known technically as the coarctate pupa), which contains the true pupa. The caterpillar, tormented by enemies feeding within it, stops feeding, and wanders about for a long time until it dies. As a rule, not more than two maggots of this fly mature in their host, and generally but one. The caterpillar attacked by a Tachina fly is always either fully grown or nearly so.

Tachina flies abounded during the whole term of the prevalence of the caterpillars, but it is impossible to state positively whether they were all bred from them or not, since the many species of this genus of flies resemble each other so closely, that a very scrutinizing investigation would have been necessary to settle such a question. But there is no doubt that they were very numerous during the summer. Some maggots obtained from caterpillars kept for this purpose in breeding jars changed to flies in six days, others appeared in twenty-three days, and still others, obtained at about the same time, are still under ground, where they will hibernate. The maggots of these flies do not, however, always enter the ground, as some were found inside cocoons made by caterpillars among rubbish above ground.

REMEDIES.

Pruning and Burning.—The old and well-tried remedies of pruning or burning, or pruning and burning, will answer every purpose against this insect in ordinary seasons, where it is thoroughly done and over a whole neighborhood. It must, however, be done upon the first appearance of the webs on the trees, and not, as was done by the Parking Commission of this city last season, after the first brood of worms had attained their full growth and many had already transformed to pupæ. The nests at that time had assumed large proportions, and their removal entire injured the appearance of many young trees. Then, too, they were piled upon an open wagon, which was dragged for many hours around the streets, permitting a large proportion of the worms to escape.

On the first appearance of the webs, which should be looked for

with care, they should be cut off or burned off; and if cut off, they should be burned at once. The "tree-pruners," manufactured for the trade and well known to all gardeners, answer the purpose admirably.

The customary method of burning the nests is by means of rags saturated with kerosene or coal tar and fastened to the tip of a long pole. An old sponge has been substituted to advantage for the rags, but probably the best substitute for this purpose is a piece of porous brick. In a pointed communication published in the *Evening Star* of August 21, Major Key, agent of the Humane Society, thus describes the making of a "brick-torch:" "Take a piece of soft brick, commonly termed salmon brick, trim it to an egg shape; then take two soft wires, cross them over this brick, wrapping them together around the opposite side, so as to firmly secure it; now tie this end to a long stick, such as the boys get at the planing-mills, by wrapping around it; then soak the brick in coal-oil, light it with a match, and you are armed with the best and cheapest weapon known to science. Holding this brick torch under the nests of caterpillars will precipitate to the sidewalk all the worms on one or two trees at least from one soaking of the brick, and it can be repeated as often as necessary. Then use a broom to roll them under it, and the work will be done, the controversy ended, and the trees saved."

A little thorough work with a simple torch like this, *at the right time*, will in nearly every case obviate the necessity of the more expensive remedies later in the season, when the worms of the first brood have grown larger, or when the second brood has appeared.

MULCHING.—After a bad caterpillar year a little judicious raking together of leaves and rubbish around the trunks of trees which have been infested, at the time when the worms of the second brood are about full-grown and before they commence to wander, will result in the confinement of a large proportion of the pupæ to these limited spaces, where, with a little hot water or a match, they can readily be destroyed during the winter. Many of the caterpillars of course reach the ground by dropping purposely or falling accidentally from the branches, but the great majority descend by the trunk, and finding the convenient shelter for pupation ready at the foot of the tree, go no farther. This has been tested on the Department grounds the past season, and is mentioned as a method of riddance supplementary only to others.

ARSENICAL POISONS.—It is seldom, however, that individuals, and still more rarely that corporations, can be brought to the use of remedies until damage is plain, and when this time comes nothing is better than the application of some one of the arsenical mixtures. We have already treated of the methods for applying such mixtures to shade trees on a large scale in our report as Entomologist to the Department for 1883, and in Bulletin 6 of this division, in both cases in connection with the treatment of the Imported Elm Leaf-beetle (*Galeruca xanthomelæna*).

The most economical and convenient apparatus consists of a large barrel, provided with a force-pump and mixer, mounted on an ordinary cart. A long hose, a metallic pipe, and a cyclone nozzle, arranged for elevation by means of a bamboo pole, complete the outfit.

Detailed descriptions of the apparatus having already appeared in the reports just mentioned, it is unnecessary to repeat them here.

A somewhat similar apparatus is used in the California orange groves against the Cottony Cushion-scale, and is illustrated in opera-

tion on Plate V. In this case a tank made especially for the purpose is mounted in the high wagon-box and secured by cleats, and supports a small hose-reel. The so-called "San José nozzle" (a direct-discharge nozzle) is used. A feature of the illustration is the long, portable ladder, which can be handled by one man. Such an apparatus as this would be well adapted for use against the Web-worm. It could be readily constructed and kept for years by the parking authorities of any city liable to the attacks of this or other leaf-eating shade-tree pests.

In the use of arsenical poisons a number of points were brought out by the series of experiments upon the Elm Leaf-beetle which are important, and which may be briefly adverted to here:

Certain trees are more susceptible to the corrosive effects of the arsenic than others. The 1883 experiments were confined to Elms, and we have no reliable data as to the relative susceptibility of other shade trees; so that we can simply mention the probability that those trees which are most liked by worms are more apt to be affected by the poison than trees which are distasteful to the worms.

"After each rain the poison takes a new effect upon the plant and the pest, which indicates that the poison is absorbed more or is more active when wet, and that it acts by dehydrating thereafter. Where the tree is too strongly poisoned each rain causes a new lot of leaves to become discolored by the poison or to fall. On some of the trees the discoloration appears in brown dead blotches on the foliage, chiefly about the gnawed places and margins, while in other instances many of the leaves turn yellow, and others fall without change of color. * * *

"The poison not only produces the local effects from contact with the parts touched by it, but following this there appears a more general effect, manifested in that all the foliage appears to lose, to some extent, its freshness and vitality. This secondary influence is probably from poisoning of the sap in a moderate degree. When this is once observable no leaf-eater thrives upon the foliage. Slight over-poisoning seems to have a tonic or invigorating effect on the trees."

In the case of the Elm Leaf-beetle it was found that a *preventive* application of the poison was valuable. It was made while the eggs were being deposited and before the young larvæ were hatched, in order to prevent the worms from getting a start. It had the additional advantage of injuring the tree less than when applied later in the season, as the caustic effect of the poison is greater when it comes in contact with the sap at the gnawed edges and surfaces of the leaves.

It was found advisable in 1883 to mix a certain amount of flour with the Paris green or London purple used, in order to render the mixture adhesive to the leaves. Three quarts of flour were used to the barrel (40 gallons) of water. Where London purple was used it was noted that the minimum amount per barrel of water was one-fourth of a pound and the maximum three-fourths of a pound. Less than the minimum did not kill the larvæ and more than the maximum injured the foliage. Three-eighths of a pound was recommended. With Paris green the quantity was somewhat greater, ranging from a minimum of one-half of a pound to a maximum of one pound.

In mixing the poison, flour and water, a large galvanized iron funnel of thirteen quarts capacity, having a cross septum of fine wire gauze, and having also vertical sides and a rim to keep it from rock-

ing on the barrel, was used. The flour was first placed in the funnel and washed through the wire gauze with water. This caused it to diffuse in the water without forming in lumps. The same process was followed with the London purple or the Paris green, according to which substance was to be used.

London purple has the advantage over Paris green in cheapness, better diffusibility, and visibility upon the foliage, and experience showed that the green seemed to injure the foliage more than the purple.

It was noticed with the Elm Leaf-beetle that the effect of a poisoning was slow in appearing; good effects are not expected before the third or fourth day. Impatience which would lead to a repoisoning on the second or third day would be apt to result in the burning and fall of the leaves.

EMULSIONS OF KEROSENE.—We have had occasion for the last few years to many times recommend the use of emulsions of kerosene against different injurious insects. We need not repeat the advantages of these preparations here, but simply state that when the Web-worms are abundant, a thorough spraying with a dilute emulsion will doubtless destroy the majority of them. On account of our absence last summer no experiments were made upon the effect of applying such an emulsion upon the foliage of the commoner shade trees, but the result of experiments detailed in Bulletin No. 11 of the Division would augur the destruction of the worms. These experiments (made by Mr. Webster at La Fayette, Ind.) were not performed upon this species, however, but upon the somewhat similar larvæ of *Pieris rapæ* and *Datana ministra*. Colonel Bowles, as we shall soon show, rejected the emulsion of soap and kerosene as not effective against the worms when reduced so as not to injure the plants; but, as he has not given us the details of the experiments, we still consider the matter open to proof. The formulæ for several emulsions are given in the article on the Cottony Cushion-scale (*Icerya purchasi*). One of the most serviceable is that which we call the "Hubbard formula," and which was used most extensively by Mr. Hubbard in his work on the scale insects of the Orange, and which has been repeatedly given in the publications of the Division.

NAPHTHA.—Some experiments were undertaken in the height of the Web-worm season by Col. John Bowles, of Washington, which possess a certain interest on account of the substance used and on account of the manner of its application. It is, however, more expensive than the arsenical poisons and the kerosene emulsions, and the spray from the atomizer is not so far-reaching as from the force-pump and cyclone nozzle. We append Colonel Bowles's condensed account of his experiments, with the remark that the experiments with the oil doubtless failed of satisfactory results because of imperfect emulsifying and application:

In accordance with your request I send herewith a concise statement of experiments made by myself in exterminating caterpillars, web-worms, &c., which destroy the beautiful foliage of our shade trees.

My experiment commenced with an effort to save the shrubbery of my yard and garden from the rapacious caterpillars that seem almost to germinate in the poplar trees, one of which stood in our front yard. After denuding this tree and literally raising an army of conquest and invasion, they broke camp and set forth as a huge foraging party, consuming everything in their way, save the rough bark of the trees and the fences.

I opposed them first with kerosene oil, which was equally fatal to the plants and worms.

Then a simple emulsion of soap in proportion of 1 to 4 was made with the oil and finally abandoned, not being effective against the worms when reduced so as not to injure the plants.

Lighter oils of the same character were resorted to and applied with a spray. This killed the vermin, yet injured the plant. Still lighter oils were used, but, when sprayed on, the foliage was materially injured. A vaporizer by means of compressed air was substituted for the spray, and with use of very light oil or naptha, known in commerce as 88, in half a second froze the worm and plant alike, with this difference, that in ten or fifteen minutes the vermin revived, but the tender leaves and twigs wilted and turned black as though struck by Jack Frost in January.

The grade of oil was reduced until the proper gravity of, say, 77 was found to kill the vermin and still leave the plant essentially unharmed.

The mechanical devices for vaporizing the oil and applying it to the upper branches of trees and shrubbery alike, as demonstrated to the Commissioners of the District some time since, and to which you kindly refer, have been since perfected, and so reduced in cost as to make the management easy by any common day laborer and the whole cost within the reach of all interested, whilst the oil costs less than 10 cents per gallon.

JOINT WORMS.

Order HYMENOPTERA; Family CHALCIDIDÆ.

THE COMMON JOINT WORM.

(*Isosoma hordei*, Harr.)

This old and well-known species has for the past few years been increasing in numbers and importance in certain sections of the country, while for a number of years previously it had been almost lost sight of. Since 1881 its work has been quite noticeable in portions of Louisa, Albemarle, Goochland, Orange, and Fluvanna Counties, Virginia, or, in other words, in just the locality where it was observed and studied thirty-five years ago by F. G. Ruffin, Professor Cabell, and Mr. Rives. Through the courtesy of Mr. F. G. Brooke, of Cuckoo, Louisa County, we have been kept informed of the progress of the pest and have been supplied with specimens from time to time.

In June, 1885, wishing to learn definitely the state of affairs in this section, and more particularly on Mr. Brooke's farm, we sent one of our assistants, Mr. Pergande, accompanied by Mr. A. Stewart, a member of the Entomological Society of Washington, to Cuckoo to make a few days' observations. The reports made by these gentlemen showed that the damage done to the wheat crop by this and other wheat insects was very great. Mr Brooke's crop for 1884 averaged less than 5 bushels to the acre, which did not pay expenses.

The Joint Worm was not alone concerned in accomplishing this result, although an important factor. The Hessian Fly (*Cecidomyia destructor*), the Wheat Midge (*Diplosis tritici*), the Wheat Isosoma (*Isosoma tritici*), the Tarnished Plant-bug (*Lygus lineolaris*), and quite a number of other hemipterous insects were present in force, and almost every straw had been injured by one or more of these species. In the portions of the field most injured the plants were often scarcely a foot in height, few in number, and many were bent near the ground, so that frequently six or eight out of a bunch of twelve were prostrate. The ears of these straws were, however, better developed and fuller of sound grain than those which stood erect. On examination the prostrate stalks were found to be badly infested by Joint Worms above the first or second joint, but almost entirely free from Hessian Fly and Wheat Midge, while the standing stalks

frequently had both of the others in addition to *Isosma tritici* and *I. hordei*. Of all these the Wheat Midge undoubtedly did the greatest and most direct damage, and many ears were found white and blasted from its work. In the most flourishing parts of the field, where the stalks were green and 4 feet high, the Joint Worm was also found, although not in such numbers as before.

The larvæ of *Isosoma tritici* were often found in the same stalk with *I. hordei*, often boring just alongside of the galls of the latter. *I. hordei*, however, were quite uniformly found just above the first or second joint, and in such position that the cutting of the grain would not disturb them, while *I. tritici* was found in all parts of the stalk from near the ground to above the upper joint.

In spite of the great abundance of the Joint Worms at this time they were less numerous than in 1884, and in 1886 they were still more reduced in numbers, owing, in great measure, to the prevalence of Chalcid parasites in 1885. The most abundant of these was *Semiotellus chalcidiphagus* Walsh, the larvæ of which were found in nearly every swelling examined. The larvæ of *Eupelmus allynii* (French) were also found, but in smaller numbers.

A study of the comparative injury done by the four principal insects found in this field would rank them in the following order: *Diplosis tritici*, *Cecidomyia destructor*, *Isosoma tritici*, *Isosoma hordei*, yet *I. hordei* alone had been complained of.

In parts of Ohio, too, the Joint Worm has been abundant. Mr. Elliot Luse, of Barry, Cuyahoga County, writing under date of May 4, 1885, complained that the previous Fall, while threshing, bits of hard straw from half an inch to three inches in length would come through with the wheat. When cleaned with a hand-mill he would get a bushel of these bits to 20 bushels of grain. The real nature of the small pieces was not discovered by Mr. Luse until spring, when, after feeding stock with chopped straw and ground feed and making them sick, the straw was examined and the insects found and sent to us for determination.

This case formed the text for an article which we wrote for the *Rural New Yorker* of June 20, 1885 (vol. 44, p. 418), in which we pointed out the necessity of cleaning with a hand-mill all wheat thrashed with a steam-thrasher from infested straw, and of burning not only the galls thus separated, but also the straw itself, as its loss can be well afforded to lessen the injury the ensuing year.

Specimens were also received from Chagrin Falls, a few miles south from Barry, in October, 1885, from Miss E. J. Phillips, who stated that the wheat straw had been badly infested in that vicinity for two years past, but that the yield did not seem to have been affected, as she knew of several fields which yielded 30 and 35 bushels per acre, and which were at the same time badly infested. The only trouble was that the little pieces of straw came through the separator with the wheat.

In Central New York the Joint Worm has also done some damage, as we learn from correspondence with Dr. Lintner, the State entomologist. Here, as in Ohio, the worms were often found higher in the stalk than was customary in Virginia. In Ohio this is shown by the fact that so many galls were found in the harvested straw, while Dr. Lintner writes us that his correspondent informed him that the worms were found "in every joint." From this he argued that it might be *Isosoma tritici*, instead of *I. hordei*, but its identity with the latter species was settled by breeding the adults at the De-

partment from straws received from Dr. Lintner, who has referred to this matter publicly in the *Country Gentleman*, vol. 49, p. 857.*

In Michigan the same insect appeared in 1884, working in the same way. In the *Rural New Yorker* for May 9, 1885 (vol. 44, p. 314), Prof. A. J. Cook described it in all stages at some length under the name of "The Black Wheat-stalk Isosoma" (*Isosoma nigrum*, n. sp.). He stated that he had received it from Wayne and Washtenaw Counties, and that at a "farmers' institute" held at Plymouth, Wayne County, in January, he found hardly a farmer who had not been vexed by the small pieces of straw, but that not one had discovered the cause.

On the appearance of Professor Cook's article we wrote to him for specimens, strongly suspecting that his new species would turn out to be the Common Joint Worm. He kindly complied with our request, and our suspicions were at once verified, and, as stated in our article in the *Rural New Yorker* (*loc. cit.*), they proved to be well-marked examples of Fitch's *tritici* form of *I. hordei*. Professor Cook is still, we believe, inclined to insist that his species is a good one, but without going into the details of our rather extensive correspondence with him in this matter, we reassert the correctness of our conclusion and pronounce the Michigan insect to be *I. hordei*.†

In conclusion we may extract a few facts from our notes bearing on the dates of transformations and the prevalence and habits of the parasites:

December 9, 1884.—Eight straws which were received from Louisa County, Virginia, July 30, were examined, with the following result: No. 1. Two parasites had issued, and the straw still contained three pupæ of Isosoma and seven larvæ of a Chalcid parasite. No. 2. Five parasites had issued, and seven parasitic larvæ still remained. No. 3. Ten parasites had issued, and one pupa of Isosoma; one living and three dead larvæ of the parasite remained. No. 4. Two parasites had issued, and six pupæ of Isosoma, and one parasitic larva. No. 5. One parasite had issued, and three Isosoma pupæ and four parasitic larvæ remained. No. 6. Two parasites had issued, and three pupæ of Isosoma and two parasitic larvæ remained. No. 7. Contained four Isosoma pupæ and three parasitic larvæ. No. 8. Five Isosoma pupæ and five parasitic larvæ. Isosoma was found only in the pupa state.

On December 17 the adult Isosomas began to issue, and they continued to appear in small numbers through January, February, March, and April, issuing most abundantly the first week in May. On May 28 straws were received from Louisa County which contained eggs nearly ready to hatch.

The breeding of 1885–'86 was very similar to this, and indicates that the periods mentioned are about normal. The adults of both sexes

* In the *American Agriculturist* for December, 1884, vol. 43, p. 531, what is evidently the same insect is treated as having been received from "Central New York," and which is there determined as *Isosoma tritici*, a reproduction of our figure of that species being also given.

† Professor Cook later republished the bulk of his first article on the subject as an original contribution to the *American Naturalist* for September, 1885 (pp. 804–808). Here he seems to be in some doubt as to the validity of his species and expresses the opinion that it will take time to "clear all this up," and says: "As species are only venerable varieties which by age have been run into the mold of variability, it really makes no great difference. Practically the matter remains the same in either case." Such reasoning would justify unlimited species-making from any one species known to be quite variable.

began to issue in numbers from Virginia straws December 19. December 31 another large lot issued, as also on January 5, January 8, and February 1.

From our breedings it becomes doubtful whether the principal parasite of the Joint Worm (*Semiotellus chalcidiphagus*, Walsh) has one or two annual generations. A few specimens were swept in the field by Messrs. Pergande and Stewart as early as June 13, while in the Department breeding-jars they issued in large numbers through July and on until August 22. Then no more were noticed until October 10, when a number were found in the jars.* During the winter straws cut open showed the presence of many of these parasites still in the larval state. April 9 a large number issued, and none after this date.

From these facts it seems that this species winters both in the adult state and as larvæ in the straws, the latter issuing in early spring. They undoubtedly oviposit in growing grain infested with *Isosoma* in the spring, and some individuals develop and issue in July and August, while others winter in the straw and stubble as larvæ. What becomes of the adults which issue so early in the season we can only surmise. It is after harvest when they appear, and to parasitize Joint Worm larvæ they would have to pierce the hard stubble or work their way into their own holes of exit or into the cut ends of the stubble; not a very likely proceeding. These early individuals may oviposit in some other host, or they may live and hibernate without ovipositing before spring.

The common *Eupelmus allynii* (French) is also, as we have elsewhere stated,† a parasite of *Isosoma hordei*, as well as of *Isosoma tritici* and the Hessian Fly (*Cecidomyia destructor*). From the Joint Worm it has also been bred from Virginia specimens, and on three dates, viz, August 22, 1884, October 11, 1884, and April 9, 1885. Although a considerable number issued on each of these dates, it appears to be only about one-tenth as numerous as the *Semiotellus*.

THE WHEAT-STRAW ISOSOMA.

(*Isosoma tritici*,‡ Riley.)

In our annual report for 1884, in describing the larger Wheat-straw Isosoma, we called attention (p. 358) to the possible relationship between this species and *I. tritici* in the following words:

"It may be here stated as an interesting fact that of the specimens so far reared both of *tritici* and *grande*, all are females, and whether or not there is any dimorphic relationship between these two forms is a question which future observations alone can decide. The probabilities are, however, that there is no connection between them, for,

*There is a possibility that some of these issued several days prior to this date.

† On the Parasites of the Hessian Fly, by C. V. Riley, Ph. D., Proceedings of the U. S. National Museum, 1885, pp. 413–422.

‡ As the object of this article is to show that the two species which we have described as *Isosoma tritici* and *I. grande* are in reality but seasonal dimorphic forms of one and the same species, it may be well to state that we retain the species name "*tritici*" as having priority, and because it represents the bisexual form of the species. We retain this name in preference to "*grande*" because, in addition to these reasons, it is an eminently appropriate name, and, as we have previously shown, Fitch's *Eurytoma tritici* is but a variety of *Isosoma hordei*, and cannot even be looked upon as entitled to a varietal name, since there is no constancy in the characters upon which it is based.

on the assumption that they represent alternate generations, we should expect the one or the other to comprise both sexes."

The history of our experiments with the two forms, in order to ascertain whether or not the relationship suggested in the above paragraph has any real existence, is briefly as follows:

Grande was first found by Mr. Webster in the summer of 1884. He observed it, and indeed bred it, early in June in Illinois, and on June 6 found females ovipositing in wheat at Oxford, Ind. On the 7th he found a pupa and a fully developed adult in wheat-stalks. The adults continued abundant until the 18th, when they began to decrease in numbers, and the last one was noticed June 27. A number of the straws in which these females were observed to oviposit in the field were sent to the Department, and a number were retained by Mr. Webster himself. From the straws sent to the Department *tritici* issued very abundantly in January and February, 1885. With Mr. Webster two premature individuals issued in October, 1884, and others issued in December, 1884, and January, and February, 1885; but all attempts to induce oviposition proved failures. No specimens of *grande* made their appearance. From straws left outdoors *tritici* issued in March and April, and again no specimens of *grande* were seen, although the straws were cut open and thoroughly examined.

This predisposed us to the conclusion that *tritici* had developed from eggs laid by *grande*, and although none of the specimens of *tritici* thus bred could be induced to oviposit in confinement, the hypothesis of an alternation of the two forms thus received strong support.

On the 2d of June, 1885, *grande* was once more observed in considerable numbers in a wheat plot, and examination showed this form present in nearly all stages of growth in the stalks. On August 12, 1885, stalks were isolated in which *grande* alone were observed to oviposit, and from these *tritici* began to issue at Washington January 7, 1886, and continued to issue on the following dates: January 15, 20, 21, 22, 23, 26, 27, and February 3, 4, 6, and 8, 1886. These all refused to oviposit, as was the case the previous winter. Mr. Webster was sent South the first of March on another investigation, and on his return to La Fayette in April found a limited number of *tritici*, which had emerged much later (probably during the latter part of March), still alive in his breeding-cages.

These specimens he at once transferred, as he states in his report, on the 12th of April, to young wheat plants grown and kept continuously under cover in a corner of his garden. These plants were carefully protected from outside insects, and on the 2d of June, 1886, the reverse of the former breeding was accomplished, and *grande* was bred from wheat in which indubitably nothing but *tritici* had oviposited! Several specimens issued in the next few days, and all immediately began to oviposit in the now nearly full-grown straw in other portions of the same stools from which they had issued.

The next step was then carried out, and these straws, in which the *bred* specimens of *grande* had oviposited from June 2 to June 12, were divided, and part sent to Washington and part retained at La Fayette, Ind., by Mr. Webster. On February 4, 1887, two female *tritici* were bred at Washington, and on the same day, as we subsequently learned, two were bred at La Fayette.

Thus the complete alternation of the two forms has been established. It will be remembered that the entire absence of a male among the many specimens of both forms bred and collected was a

stumbling-block to our acceptance of this hyphothesis in 1884 before the alternation had been proven, and it so remained until January 6, 1886, when a male Isosoma was bred by us from the same straws in which *grande* was observed ovipositing by Mr. Webster at La Fayette August 12, 1885, and which had since been isolated, and from which female *tritici* were being bred and were subsequently bred in numbers. On February 4 another of these males was bred from this lot of straw, and on February 6 still another, making three in all. In size these males were slightly smaller than the females of *tritici*, and of course much smaller than *grande*. They were all three fully winged, and could have been nothing else than the males of *tritici*. Attempts were made while they were yet alive to establish this beyond all peradventure by placing them with living females of *tritici* bred from the same straws and also with living females bred from straws received from California. The result was unsatisfactory. The males were lively and ran actively about in the breeding-jars, but made no attempt to pair. As soon as they came in contact with the females they either flew away or dropped as if startled. They were watched, however, only during the daytime from 9 a. m. until 4 p. m., and were in confinement in breeding-jars in the Divisional laboratory. All males died after three or four days, and none of the males issued on the same day with the females, so that one or the other was weak when watched with the opposite sex. It is also probable that the artificial conditions of a vivarium are unfavorable to proper development or maturity of the specimens, and that freedom and sunlight are essential to coition.

This breeding of the males, although not perfectly satisfactory, removes the last obstacle to the acceptance of the fact of alternation of generations with this species; for we must now call it a single species. The summary of its life-history in Indiana is as follows:

In March and April there issue from old last year's straws, either stubble or volunteer, wingless females of the *tritici* form, with, in some seasons, males. These oviposit in growing wheat. In June the winged females of the *grande* form issue from this same wheat, with, so far as known, *no* males. These oviposit in the now nearly grown straws of wheat, and from these eggs hatch larvæ which mature before winter and give forth adults of the *tritici* form early the ensuing spring.

From this summary it will be seen that it is the *grande* form alone which does the damage in Indiana; and supposing this relationship to hold wherever the species occurs, it effectually relieves those northern regions where only spring wheat is grown from any anticipation of injury, and indicates the obvious remedy of destruction of stubble and volunteer grain in the cultivation of winter wheat. In localities where both winter and spring wheat are grown we should expect to find the insect the most numerous.

Bearing out this suggestion, we may state that we have received the insect from no portion of the country in which spring wheat exclusively is grown.

We have used the above qualifying clause as to the alternation of generation in these two forms in all sections where the species occurs, for the reason that while *grande* has been found only in Bloomington and Normal, Ill., and Oxford and La Fayette, Ind., *tritici* has been sent to us from Virginia, Indiana, Illinois, Tennessee, Missouri, Kansas, California, and Washington Territory.

Mr. J. F. Donkin, of Grayson, Stanislaus County, California, wrot

us under date of May 23, 1885, sending specimens, and again on June 19. Mr. Coquillett, writing from Atwater, Merced County, California, June 29, sent similar specimens. Mr. Donkin, in his first letter, said: "They are killing a large percentage of our wheat. The heads turn yellow and die long before the wheat ripens." In his second letter he supplemented this as follows: "I send you by this mail samples of wheat-straw taken from different fields several miles apart. I am told by friends who have been growing wheat for years on the same land that the worms are in all the wheat this year. They have found it in the wheat of every field examined. There is a difference of opinion about the damage done by it. Some say that when we have plenty of rain and the wheat is thrifty it does no harm. One told me that he had noticed pieces of about one-eighth of an acre in extent where about one-eighth of the heads had no wheat. Last year was the first that I saw any myself."

That this insect has existed in California for a number of years there can be no doubt from the evidence of correspondents. It is probably the same insect which was sent to Dr. Packard through the *Pacific Rural Press* in September, 1879, from Healdsburg, Sonoma County, California, and which was identified by him as a wingless Joint Worm. Other specimens were received by him the same year from Madison, Yolo County. It was also received by us in September, 1882, from Mr. J. A. Starner, of Dayton, Columbia County, Washington Territory, in stalks which contained larvæ and pupæ. Although the work and early stages were precisely similar to those of *tritici*, the great difference in locality led to the presumption that it might be a different though related species, but subsequent breeding of the adults settled the question of identity.*

The presence of this insect in the other States mentioned has already been placed on record, with the exception of Kansas. From this State we received specimens in July, 1885, from Mr. Warren Knaus, of Salina. The straws contained larvæ which were dried up on receipt, so that it was impossible to say to which form they belonged. The work in the straws indicated either *tritici* or *grande*, while the date of collecting (July 5) rendered it more probable that they were *grande*. As this is the first recorded finding of *Isosoma* in Kansas, we may quote briefly from Mr. Knaus' account:

"I mail you to-day a box containing specimens of what I take to be *Isosoma tritici*. The joints infested are all the second from the ground, and are the only ones in the stalk of wheat containing the worm. Stalks from various fields are almost all infested, many containing three larvæ. I have taken a number of larvæ from immediately above the joint next the head. My observation is that these worms have caused more damage to the wheat in this part of the State than the Hessian Fly fully 50 per cent. of the heads in many fields of wheat showing their work in a very marked manner."

In a letter dated August 16 he gives the following:

"I have just returned from a trip through Northwest Kansas, and find that the Wheat-straw Worm has seriously damaged the wheat in the counties of Ottawa, Cloud, Osborne, Rooks, and Phillips; also in Saline, McPherson, and Dickinson Counties. It has really done more damaged than the Hessian Fly."

In order to compare the customary situation and abundance of the larvæ in the straw in California with Mr. Knaus' statement and with

*See *American Naturalist*, December, 1882, p. 1017.

Mr. Webster's table in our last Annual Report (p. 386), we give the result of an examination of ten straws received May 23 from Mr. Donkin, of Grayson, Cal.:

Above fourth knot from ear	3
Above third knot from ear	12
Above second knot from ear	15
Above first knot from ear	5
In second knot from ear	2
In third knot from ear	6
In fourth knot from ear	1
Total number of larvæ in ten stalks	44

PARASITES.—By far the most numerous parasite bred during the season from both the bisexual and unisexual forms has been *Eupelmus allynii* (French). But one specimen (female) of *Stictonotus isosomatis* Riley, which we described in our Annual Report for 1881–'82 (p. 186), has been reared since the original description, which was drawn up from one female and two males. We have, however, bred a most interesting parasite of the Proctotrupid genus *Dryinus* from the *grande* form and a new Pteromalid from both forms.

SILK CULTURE.

In our last Annual Report we reiterated the recommendations which we had several times made that means be given for the establishment in Washington of an experimental silk filature, and expressed the hope that we should be able to obtain a certain number of Serrell automatic reels with which to carry out any experiments which might be authorized.

In pursuance of this recommendation Congress, at its last session, appropriated $10,000 in aid of silk culture, and, among other things, authorized "experiments with automatic machinery for reeling silk from the cocoon at some point in the District of Columbia." The experimental reeling station at New Orleans had been closed at the beginning of the calendar year, and on the 30th of June that at Philadelphia was also closed and its appurtenances loaned to the Women's Silk Culture Association, in aid of which Congress also appropriated $5,000.

In pursuance of this act (June 30, 1886) an experimental silk filature has been set up in one of the Department buildings in Washington. It consists of a battery of six Serrell automatic reels and an automatic cocoon-brushing machine, invented partly by the same engineer.

Several objects will be held in view in operating this establishment. Among them we shall endeavor to settle conclusively the commercial value of Osage Orange as a silk-worm food, and, more important still, as foreshadowed in our last report, will be the determination of the question as to whether silk can be reeled with profit in the United States by means of the most improved machinery.

OSAGE ORANGE VS. MULBERRY.

In reference to the first object, the work already done justifies the statement that cocoons raised from Maclura-fed worms produce as good a silk as when the worms are fed on Mulberry. The difficulty found when these cocoons were reeled in France was that the rendi-

tion* was too great, being in the neighborhood of 5, while 4 is only a fair result with white-mulberry cocoons.

The second week's work in the Washington filature on Osage Orange cocoons gave a rendition of 3.69, and subsequently a result as low as 3.65 has been attained. This result was reported to Mr. Serrell, the inventor of the reels used, who, though living abroad, has always taken a lively interest in American silk culture, and his comments thereon are so encouraging that their substance is presented here:

The rendition from Osage Orange cocoons at the Washington filature is astonishing. So far as I know, the only time they have been reeled in France they gave a rendition of nearly 5. That is to say, as reeled in France it took a pound and a third more cocoons to produce a pound of silk than in the work done in Washington. It is fair to say, however, that in France they were reeled in a filature accustomed to only the best French cocoons.

"Be that as it may, the result attained is extremely remarkable, and makes me foresee a prompter outcome from American cocoons than I had supposed was possible.

Of the silk mentioned several skeins were taken to New York and submitted to the most rigorous tests at the Silk-conditioning Works in that city. It is needless to go into the details of the technical report made by its manager, but it will suffice to say that this Osage Orange silk gave excellent results, the faults being such as can be cured as our silk-raisers gain in experience.

The use of Osage Orange as a food-plant has now become quite general in the States where it is plentiful. Some observations which have been made on cocoons raised therefrom may be of service to the raisers who employ it. If two batches of cocoons be taken, raised from the same eggs, the one on the Mulberry and the other on the Osage, they will to the ordinary eye possess no distinct characteristics. The expert, however, can at once and almost unerringly designate the food used in either case, and this on account of the greater degree of satinage observable in those produced by the Osage Orange-fed worms. It was explained in the last edition of our manual that this satinage consisted of an inferior gumming together of the layers of the cocoon, and is made apparent to the eye by the coarser texture of its surface. As a result, the water penetrates to the interior, and causes them to sink to the bottom of the basin in reeling, and thus to break off the filament. Although this difficulty has not been proved to be the result of any given cause, still it is generally believed to be due to the insufficient feeding of the worm during the last days of its life. At this time almost all of its food goes to the formation of silk, and though a worm may make its cocoon if the feeding is stopped five days after the last molt, still it will be weak and commercially useless. In order that it should be strong and well garnished, no food should be spared at this time. The almost universal difference found between the cocoons raised on Osage Orange and Mulberry in this particular leads to the opinion that a greater quantity of the former food is required than of the latter, and that our people have not learned to supply their silk-worms with enough liberality during the days which precede the spinning.

What has been said above must not be construed as a serious objection to the use of such food, but simply as an indication of how it may be used with greater advantage than at present. On the con-

*By "rendition" is meant the number of pounds of dry cocoons required to produce a pound of reeled silk.

trary, though nothing definite can be said as to the result of the limited experiments already made, the indications point to Osage Orange as at least the equal of Mulberry as silk-worm food, and confirm in continuous reeling the conclusions arrived at in previous years, and which we have reiterated in past writings.

THE SERRELL REEL—COST OF WORK UP TO THE PRESENT TIME.

In regard to the more important feature of our experiments we have not yet gone far enough to be willing to venture any opinion upon the probable outcome of the work. The limited appropriation prevented the setting up of more than six reels, though we had hoped to obtain twelve. Even with these six it has been somewhat slow work to train the young girls employed in their operation, and the consequent sale of the silk produced has been delayed longer than we anticipated. But at the best we cannot this year hope for results which will be more than indicative of the future prospects of the industry; for there are so many items of loss in the operation of a small establishment, which would not occur in a larger one worked under what we may call factory conditions, that it is impossible to make altogether accurate estimates. We shall be able, however, to show the silk manufacturers of the country what quality of silk can be made from American cocoons, and to give capitalists some indications of the probable profit to be realized or loss to be suffered in working a filature supplied with the best machines. We hope to be able to give in our next annual report the result of at least nine months of work under as favorable conditions as are possible with a small establishment.

The expenses of the operation of the experimental filature have been so far as follows:

	Per week.
1 forewoman	$8 65
5 operatives	23 08
Total	31 73

Or of each of the five reeling days, $6.35.

It has been found best to reel forty hours per week, and employ the time Saturday in sorting cocoons, so that the above sum ($6.35) includes the total expense for productive labor employed in making one day's product.

Only five of the reels have been in operation. The best product made on the five reels mentioned has been 850 grams per diem (1.87 pounds).

This silk has cost us:

For labor as above	$6 35
For cocoons	7 29
Total	13 64
The value of the product would be, at minimum figures (1.87 pounds of silk, at $5)	9 35
Waste	1 50
Total	10 85

This will show a daily loss of $2.79, or a loss of approximately $1.50 per pound of silk produced, not including interest on capital involved or cost of superintendence. It is not a very good showing,

and we quote Mr. Walker's conclusion as to the chances of improving it:

"I am of the opinion that saving can be made in the following ways: In the present machines the two threads of each basin are so dependent upon each other that when one thread breaks the reels of both threads stop. Judging from the result of carefully noted experiments within the past week, I am of the opinion that if these threads were made independently of each other the daily production would be increased by 125 grams without increase of the labor employed. Again, the two girls at the reels, owing to their slight experience, are unable to keep the threads sufficiently free from almost exhausted cocoons, and as a result bunches run up into the *croisure* and cause the rupture of the filament. By careful noting of the time lost by these breakages I found that it amounted to 29 per cent. of the working day. I put Mrs. Vaccarino in the place of the two girls, and by her superior ability in taking out exhausted cocoons she diminished the loss of time to slightly over 6 per cent. It is probable that with properly constructed *purgeurs* the ratio of time lost would be reduced as low as 10 per cent. And I am now experimenting with some devices which justify, I think, my hopes of arriving at such a result. If I do succeed, I shall, without increasing my labor, increase my production from 1.87 pounds to 2.37 pounds.

"This silk will require in its production:

For labor	$6 35
For cocoons	9 24
Total	15 59

"The product will be worth:

Silk	$11 85
Waste	2 00
Total	13 85

"This would reduce the daily loss to $1.74, or the loss per pound of silk produced to 74 cents."

THE DISTRIBUTION OF EGGS.

In 1885, as stated in our last report, a quantity of silk-worm eggs were purchased of American silk-raisers and 150 ounces were distributed to applicants in different parts of the country. The general result was so unsatisfactory as to prevent the repetition of the experiment. There were but few of the sellers who had the slightest idea of the care to be taken in egg production, and it has not been thought wise to continue the encouragement of this kind of work. There is, too, undoubtedly, evidence of the existence in the country of much "seed" of inferior races, and it is our aim to prevent the use of this as much as possible by the gratuitous distribution of choice qualities. In 1885 our distribution was confined to the class of races commonly called the large Milan, and the same policy will be followed in 1887. Silk-raisers who have had cause to be dissatisfied with their stock, either from failure in their education or from poor prices received for their product, will do well to apply to the Department for a new supply.

The reason for confining the distribution of eggs to the large Milan

races is one dictated by the necessities of the case. They have, as a rule, been submitted to the Pasteur microscopical selection, which is not true of Asiatic stock. This would have been of little importance some years ago, but now there is good evidence of the existence of the pebrine in Japan and China, and the only means of guarding against it is by avoiding the purchase of such material.

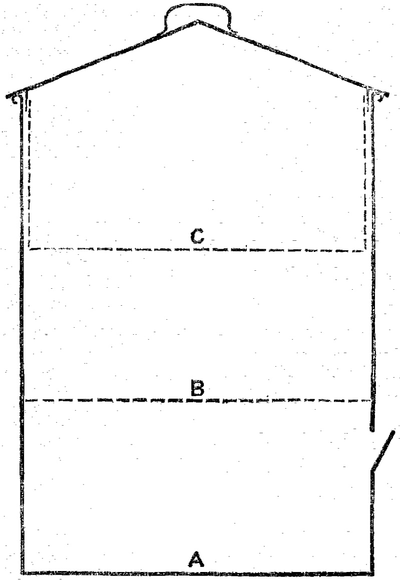
Of the Milan races, then, stock of assured purity may be obtained. The worms are hardy and the cocoons give excellent results in reeling. The few reeling establishments now existing or likely to exist in the United States in the near future can consume but a comparatively small quantity of cocoons and produce but a small quantity of silk. In order to find a ready market for such silk it must be of good quality, a term which includes among other things evenness of color. To produce this evenness we must have not only cocoons of the same color, but as much as possible of the same shade. The use of the many races now in vogue in this country prevents the attaining of this desirable end, and the cocoons that are offered at the filature are not all that can be desired in this direction. It is true that we might choose some of the other European races that are as carefully selected, such, for example, as the Bionne, but taking everything into consideration, the conditions sought for are best found in the large Milan varieties.

Last spring some of this sort of eggs, produced by the house of Darbrousse, in France, were sent to us by a gentleman in New Orleans, and a few of them were raised in the Department building, the food employed being Osage orange. There were almost no deaths in the batch, and about 4 pounds of cocoons were produced. It took 256 of these to make a pound, while 300 is considered an extremely good result. Part of the best of these were selected for reproduction, and were found to weigh a pound to each 216. Such cocoons as these are what silk-reelers want and are willing to pay extra prices for, but unfortunately there are few of them offered.

IMPROPER CHOKING OF COCOONS.

Our experience in the filature, too, has shown us that our people are sadly deficient in their knowledge of the art of stifling cocoons, and many lots have been received which were of otherwise excellent quality, but which had been burned by the employment of improper means for destroying the life of the chrysalis. It is the custom in Europe for the silk-raiser to dispose of his cocoons at the filature as soon as they are raised and before they have been stifled. The raiser then has the advantage of getting payment for his work as soon as it is completed, and the silk-reeler is enabled to stifle his cocoons in large quantities and by the most approved process. This scheme, however, has thus far been found impossible in the United States, as the silk-raisers are as a rule located so far from the available markets, that there would be danger of the moths piercing the cocoons before they could be choked. American buyers have therefore been obliged to purchase only stifled cocoons which have been thoroughly dried, and as this process of drying requires several months, silk-raisers have not received the proceeds of their season's labor until well into the autumn. And again, through inability to purchase apparatus or through lack of knowledge on the subject, they have resorted to such means of stifling as were at their command, and have destroyed in many cases an otherwise excellent crop. This burning of the cocoons

may always be obviated by using steam in their stifling and afterwards thoroughly drying them to prevent molding. A very efficient though simple piece of apparatus for thus stifling cocoons was purchased last spring by this Department of the New York Silk Exchange, and is within the means of most silk-growers. A sketch of it, in a slightly modified form, is given at Fig. 1. It consists of a tin reservoir, A, which, when in use, is about one-third filled with water. Slightly above the surface of the water is a movable perforated partition, B, intended to prevent spattering during ebullition. The uppe rportion contains a perforated pan for holding the cocoons, while all is tightly closed by a cover. Cocoons may be thoroughly stifled by exposure in this apparatus over boiling water for twenty minutes. It will be seen, too, that much the same apparatus can be contrived by the use of a deep kettle, into which is set an ordinary colander full of cocoons. It is well to avoid, however, so filling the kettle with water that it will splash upon the cocoons in boiling, as they should only be subjected to the action of steam. The apparatus owned by the Department is 12 inches in diameter and 13 inches deep, and will stifle from 3 to 4 pounds of cocoons at a time.



COCOONS PRODUCED IN THE UNITED STATES IN 1886.

Desirous of getting some statistics as to the amount of silk produced during the year in this country, and believing that the result could be approximately obtained by summing up the receipts at Washington and Philadelphia, we applied to Mrs. Lucas, who has kindly furnished the data from the Women's Silk-Culture Association of Philadelphia, of which she is president. These receipts are for the first half of the fiscal year, or from October 1, 1886, to the end of the year. They do not include whatever silk was raised in California, and will probably be materially increased by receipts during the first quarter of 1887. The result is, however, quite interesting, and the more so that no impetus was given to the raising of the cocoons by the establishment of the filature at Washington (and the same may be said in a great measure of Philadelphia), since the appropriation did not become available until after the silk-raising season was over.

Figures show that during the time stated there have been purchased at the Washington filature 1,313 pounds 15 ounces, valued at $1,272.04, and by the Women's Silk Culture Association at Philadelphia, 3,801 pounds 9 ounces, valued at $2,720.88. This makes a total of 5,115 pounds 8 ounces, for which there was paid the sum of $3,982.96, or nearly 78 cents per pound. These were obtained, as will be seen by the following table, from twenty-six States and Territories. It is probable that the table is not a just indication of the production

of those States, as there have been certain cases where lots of cocoons have been received at the filature which were the results of collections made from many different raisers and which were possibly not raised in the State from which they were purchased.

State.	Philadelphia.		Washington.		Total.		Average value per pound.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Lbs. oz.	*Dollars.*	*Lbs. oz.*	*Dollars.*	*Lbs. oz.*	*Dollars.*	*Dollars.*
Alabama	1 12	0 70	5 10	6 04	7 6	6 74	0 91
Arkansas	30 1½	15 40	5 1	3 54	35 2½	18 94	54
District of Columbia	....	....	3 12	3 32	3 12	3 32	885
Florida	56 2½	52 24	8 2	4 05	64 4½	56 29	88
Georgia	18 6½	11 38	0 12	78	19 2½	12 16	63
Illinois	780 2	622 33	249 7	241 12	1,029 9	863 45	838
Indiana	140 13	100 80	85 8	81 70	226 5	182 50	805
Iowa	165 2	111 68	3 2	3 59	168 4	115 27	685
Kansas	596 7	351 85	57 5	61 08	653 12	412 93	63
Kentucky	67 10	38 80	5 12	6 11	73 6	44 91	61
Louisiana	9 6¼	8 72	162 8	172 54	171 14¼	181 26	89
Massachusetts	4 6	3 41	....	....	4 6	3 45	788
Michigan	241 12	223 18	4 12	5 46	246 8	228 64	92
Mississippi	3 10	1 27	111 2	86 49	114 12	87 76	76
Missouri	267 13	194 45	125 12	129 04	393 9	323 49	82
Nebraska	71 3	32 18	116 11	125 78	187 14	157 96	84
New Jersey	8 8½	8 14	3 4	3 25	11 12½	11 39	966
New York	3 5	2 81	3 3	2 86	6 8	5 67	87
North Carolina	95 7	49 36	37 3	41 23	132 10	90 59	68
Ohio	1,063 11	780 13	121 5	113 13	1,185 0	893 26	75
Pennsylvania	54 4¼	40 55	144 4	115 40	198 8¼	155 95	78
South Carolina	9 4	4 77	....	....	9 4	4 77	515
Tennessee	37 0	13 56	2 3	2 18	39 3	15 74	40
Texas	11 12½	6 99	40 10	39 97	52 6½	46 96	89
Virginia	60 10½	42 80	15 4	11 95	75 14½	54 75	72
West Virginia	3 0	3 38	1 7	1 43	4 7	4 81	1 08
Total	3,801 9¼	2,720 88	1,313 15	1,262 04	5,115 8¼	3,982 96	772

REPORTS OF AGENTS.

REPORT ON REMEDIES FOR THE COTTONY CUSHION-SCALE.

By D. W. Coquillett, *Special Agent.*

LETTER OF TRANSMITTAL.

SIR: The following pages comprise my report upon the experiments to destroy the Cottony Cushion-scale (*Icerya purchasi*, Maskell).

In accordance with your letter of instruction I proceeded to Los Angeles on the 9th of February, 1886, and had a conference with the County Horticultural Commission relative to the best place for me to to locate in order to study to the best advantage the life-history and habits of the Cottony Cushion-scale, and they assured me that they could find such a location in the city of Los Angeles, but wanted time to enable them to make the necessary arrangements. Accordingly I returned to Anaheim, and on the 15th of February again visited Los Angeles, and was shown several orchards, in either of which I could carry on my investigations. I chose the Wolfskill orchard as offering the best opportunities for my studies, and was not a little influenced in my choice by the fact that I would thereby secure the aid of the superintendent of this orchard, Mr. Alexander Craw, whom I found to be a most careful and accurate observer of the habits of insects in general, and who has had considerable experience in combating scale insects of various kinds.

In this orchard I carried on my experiments with various remedies for the destruction of the Cottony Cushion-scale, and it was here that the greater number of my observations upon the history and habits of this insect were made; but I also studied it in many of the other orchards and yards in various parts of this city.

On the 18th of June, 1885, the board of supervisors of Los Angeles County passed an ordinance relating to the destruction of insect pests. In accordance with this ordinance the office of County Board of Horticultural Commissioners was established, and Messrs. J. R. Dobbins, George Rice, and S. McKinley were appointed to

the board. It is the duty of this commission to divide the county into districts and appoint an inspector for each district. When trees or plants are found to be infested with the Cottony Cushion-scale or other injurious insect the owner is notified of this fact and is requested to disinfect such trees or plants, and if he fails to do so within due time his premises are deemed a public nuisance, to be proceeded against as any ordinary nuisance until abated.

On the 4th of August, 1885, the city council of the city of Los Angeles passed an ordinance declaring trees and plants infested with the Cottony Cushion-scale within the city limits a public nuisance immediately, and it also established the offices of inspectors of fruit pests, whose duty it was to see that the provisions of this ordinance were enforced.

On the 13th of November, 1885, the board of supervisors of Los Angeles County offered a reward of $1,000 for a perfect exterminator of the Cottony Cushion-scale, and the horticultural commission and myself were appointed by the board to act as a committee for determining the efficacy of the various remedies presented by the different applicants for the above reward. Up to the present writing there have been eleven applicants for this reward, and these have made thirty-eight tests, but none of these remedies have been deemed worthy of the offered reward.

In the prosecution of my studies I have been not a little aided by the above commission and their able corps of inspectors, to all of whom my warmest thanks are due. Mr. Albert Koebele, one of the agents of the United States Division of Entomology, has been with me part of the time, and has aided me much in the mechanical part of my experiments.

Respectfully, yours,

D. W. COQUILLETT.

Prof. C. V. RILEY,
United States Entomologist.

GENERAL CONSIDERATIONS.

The great desideratum in a remedy for scale insects is that it shall kill all of the insects and their eggs without producing any injury whatever to the tree or fruit, and to this must be added the additional qualification that it must be reasonably cheap. A wash costing from 1 to 1½ cents per gallon would be cheap enough to be extensively used, while if it should exceed 3 cents per gallon it would be beyond the reach of the majority of the fruit-growers.

It is no difficult task to discover a wash possessing any two of the above qualities; but to discover one which possesses the three properties combined is a far more difficult matter.

The remedies in common use in Southern California for the destruction of the Cottony Cushion-scale consist of various liquid solutions applied to the infested trees in the form of a spray. The usual appliances for performing this operation consist of a force or spraying pump mounted upon a barrel or tank; to the pump is attached from one to four pieces of rubber hose from 15 to 20 feet in length, and to the end of each is attached an iron tube measuring from 4 to 10 feet in length. The nozzle commonly used is known as the "San José" nozzle, and is fastened to the outer end of the iron tube above described.

This nozzle consists of a short brass tube, upon the outer end of which is screwed a brass cap having a large opening in the top. This cap holds in place a circular piece of brass, in the center of which is a small slit, through which the solution is forced in the form of a fan-shaped spray. Sometimes a piece of rubber is substituted for the circular piece of brass in the nozzle; it has the advantage of not becoming clogged so easily as the brass one, but is far less durable.

The Cyclone nozzle, which has been fully described in previous reports of this Department, has been used by a few different persons here, but these, with one accord, prefer the San José nozzle. For thorough work, however, the Cyclone nozzle is to be preferred, as it does not become clogged so easily as the San José nozzle, and it also permits the operator to spray the leaves from all directions, the spray issuing from the side of the nozzle instead of from the outer end, so that by simply turning about the iron tube carrying the nozzle the spray can be thrown in all directions.

This defect in the San José nozzle is overcome to a certain extent by means of a ladder, by the use of which the tree can be sprayed both from above and from below. For this purpose an improved ladder, mounted upon wheels, is now coming into use. This can be wheeled from one tree to the other, and being provided with the proper supports, does not rest against the tree itself. In this way the operator can move up and down the ladder without being hindered by the branches of the tree he is operating upon. (See Plate V.)

Even the most skillful operator, however, when equipped with the best of appli-

ances, will find it to be absolutely impossible to spray the solution upon *every* insect on the tree, as a few are quite certain to escape, protected, it may be, by a curled leaf or similar object. Much can be done to aid in properly spraying the trees by first removing from the tree, especially from the inside of the top of it, all of the branches that can possibly be spared. This will not only greatly expedite the task of spraying and make it more efficient, but will make a great saving in the quantity of the solution required, thus lessening the cost of spraying in proportion to the number of branches removed.

Another item of importance is to prevent the great waste of that portion of the solution which ordinarily falls upon the ground after having been sprayed upon the trees. This can be accomplished by using some simple contrivance for catching the solution in such a manner that it can be made to flow into a tub or other vessel, being in the mean time strained from all extraneous substances; it can then be emptied into the tank or barrel to which the spraying-pump is attached and thus be used over again. It has been ascertained that fully *two-thirds* of the quantity of the solution first used could in this way be saved and with but very little additional labor.*

As illustrating the extreme tenacity of life with which the female Cottony Cushion-scale insect is endowed, I may state a fact that I have frequently witnessed, namely, that an adult female, with her egg-case attached, when sprayed with a solution so caustic that her back was burned black and was hard and wrinkled, still retained the use of all of her organs three weeks after the application of the solution had been made. In such instances the cottony egg-sac had been hardened and discolored by the solution, and the addition to it which the female had excreted after the application of the solution was very conspicuous by its whiteness.

Several persons have succeeded in clearing their trees of the Cottony Cushion-scale by simply spraying them with pure cold water thrown upon the trees with considerable force, repeating the operation once or twice each week until all of the insects have been removed from the trees.

When once these insects have inserted their beaks into the bark of the tree it is quite impossible to extract them from the bark by any forcible means that we may employ, as the beak is very brittle and easily broken off short to the body. It is doubtless owing to this fact that the water remedy referred to above is so effective when employed against these insects, as the beaks are broken off in dislodging them from the tree, and the insects, thus deprived of the organ through which their food is obtained, must necessarily perish of starvation.

This method is practicable only in places where but few trees are to be treated; it is much too laborious and requires repetition too frequently to be used on a large scale.

Following is a summary of the experiments which I have made with various remedies for the destruction of the Cottony Cushion-scale. For spraying these solutions upon the trees I used a Johnson pump and a Cyclone nozzle.

In making these experiments it has been my aim to discover a remedy that would prove fatal not only to the insects in their various stages of development but also to the eggs, as it will be easily seen that if the latter are not destroyed they will in due time hatch out, and thus again stock the tree with these pernicious pests.

Of course a remedy that merely destroys the insects could be used with good success by making a second application at an interval of about two months after the first one, thus giving the eggs time to hatch out; but this would require double the labor and cost of a single application and the risk of injuring the tree would also be much greater.

CAUSTIC POTASH.

The crude potash was dissolved in water and the solution then sprayed upon the trees. The cost of the potash at wholesale is about 7 cents per pound.

One Pound of Potash dissolved in one Gallon of Water.—An hour after the application the leaves upon the newest growth on the tree had sensibly withered; nine days later about one-half of the leaves had dried up and fallen from the tree. Two months after making the application one-tenth of the smaller lateral branches had become dead and dry, while upon the other branches a new growth had started. About 95 per cent. of the insects and 60 per cent. of the eggs were killed; the insects which es-

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*Such a drain-table has already been made and used at San José for the purpose indicated. It is described in the first report of the State Board of Horticultural Commissioners, 1882, p. 83, in Mr. Chapin's report, as follows: "The table is made of sheet-iron and zinc, fixed upon a frame in halves, which are placed against the trunk of the tree on either side, thus forming a circular basin 14 feet in diameter, and requiring but one minute for transfer from one tree to another. * * * The saving caused by this was at least two-thirds of the material."

caped injury were those in the adult stage, both before and after excreting the egg-mass.

One Pound of Potash and two Gallons of Water.—This killed about one-tenth of the leaves upon the tree and several of the smaller branches. All of the insects in the first and second stages were killed, but only about one-half of the adult females, one-fourth of the females with egg-masses, and one-tenth of the eggs were killed.

One Pound of Potash and four Gallons of Water.—This killed about 5 per cent. of the leaves and burned brown spots of various sizes in many of the others. Nearly all of the insects in the first and second stages were killed, but not more than one-fourth of the adult females before secreting the egg-masses were killed, while the females with these egg-masses were scarcely affected by the application; eggs uninjured.

CAUSTIC SODA.

The crude caustic soda was used; the present price of the soda is 5 cents per pound when purchased in large quantities.

One Pound of caustic Soda dissolved in two Gallons of Water.—This killed all of the leaves upon the tree and burned the bark brown, but later in the season the tree put forth a new growth on some of the larger branches. All of the insects were killed, with the exception of about one-tenth of the adult females before secreting the egg-masses and one-eighth of those with egg-masses; eggs scarcely injured. (In one of the egg-masses situated upon a spot where the bark had been burned brown I found three recently hatched larvæ five days after making the application.)

One Pound of caustic Soda to four Gallons of Water.—This killed about four-fifths of the leaves and one-third of the smaller branches, and burned the bark brown in large spots. With the exception of about one-sixth of the adult females before secreting the egg-masses and one-fourth of those with egg-masses, all of the insects were killed; eggs uninjured.

One Pound of caustic Soda to six Gallons of Water.—This killed about one-third of the leaves upon the tree, while the bark was not injured. A slightly larger number of the adult females escaped injury than in the preceding experiment; eggs uninjured.

Several egg-masses were immersed in a solution composed of 1 pound of caustic soda dissolved in 1 gallon of water; this killed about one-third of the eggs thus treated.

HARD SOAP.

This was a brown laundry soap, manufactured by the Los Angeles Soap Company, under the name of "Our Favorite German Chemical Soap," and I am informed by one of the members of the above firm that this soap is composed of tallow, caustic soda, a little sal-soda, and resin. It is retailed at the rate of 5 cents per bar, weighing somewhat less than a pound, but it could probably be obtained at wholesale at the rate of 3 cents per pound. It was first dissolved in hot water and afterward diluted with cold water, and sprayed upon the trees when quite cold.

One Pound of Soap and two Gallons of Water.—This left a whitish coating upon the leaves and bark of the tree, but did not appear to injure the latter. It killed all of the insects with the exception of about 1 per cent. of the females with egg-masses, and hardened the outside of the egg-masses to such a degree that the insects after hatching were unable to make their way to the outside world. Fully four-fifths of the eggs were thus virtually destroyed.

One Pound of Soap and three Gallons of Water.—This also left a whitish coating upon the leaves and bark. All of the insects were killed with the exception of about 4 per cent. of the adult females, before secreting the egg-masses and 8 per cent. of the females with egg-masses. About three-fourths of the eggs were destroyed in the manner related above.

Several of the egg-masses were immersed in a solution composed of 1 pound of the soap to 1 gallon of water, and not a living insect issued from either of the egg-masses thus treated.

It is necessary to spray these solutions when quite hot, since the cold solutions are of such a thick consistency that it is very difficult to force them through a spraying nozzle.

SOFT SOAP.

This was made by dissolving 1 pound of refined potash and 1 of concentrated lye in 3 gallons of water, to which was added one-half gallon of fish-oil. This was boiled for about one hour, when 4½ gallons of water were added. The cost of these materials when purchased in large quantities is about as follows: Potash and con-

centrated lye, each about 10 cents per pound; fish-oil, 35 cents per gallon. The materials used in making the soap above described made about 66 pints of soap, at a cost of 37 cents, being a trifle over half a cent per pint.

Two Pints of Soap in one Gallon of Water.—This proved fatal to all of the insects with the exception of about 10 per cent. of the adult females. About three-fourths of the eggs were destroyed, the solution having the property of hardening the egg-masses.

One Pint of Soap in one Gallon of Water.—This proved fatal to all of the insects with the exception of about one-third of the adult females, but not more than one-third of the eggs were destroyed.

KEROSENE EMULSIONS.

An emulsion was made by dissolving half a pound of hard soap in 1 gallon of water, and adding it, boiling hot, to 2 gallons of the best grade of kerosene (150° fire-test), and forcing this through a spraying-pump back again into the vessel containing the solution. This was continued for about twenty minutes, when a very good emulsion was formed.

This emulsion was used in various proportions from 1 part of the emulsion to 6 parts of water, to 1 part of the emulsion to 18 of water. Neither of these solutions produced an injurious effect upon the trees operated upon.

One Part of the Emulsion to six Parts of Water.—This proved fatal to all of the insects with the exception of about 6 per cent. of the females before secreting the egg-masses and 10 per cent. of those with egg-masses. Nearly all of the eggs were killed.

One Part of the Emulsion to nine Parts of Water.—This was fatal to only about one-third of the adult females and a somewhat larger proportion of the young ones. About four-fifths of the eggs were destroyed.

A number of the egg-masses were immersed in the undiluted emulsion, and none of the eggs thus treated hatched out.

An emulsion of the same grade of kerosene as that used above was formed of 2 gallons of kerosene and 1 gallon of sweet milk. This formed a better and more stable emulsion than the one made with soap-suds, but its effects upon the insects were not as good as those produced by the latter emulsion.

A solution composed of 1 part of this emulsion to 6 parts of water killed nearly all of the young insects, but proved fatal to only 10 per cent. of the adult females with egg-masses. About one-half of the eggs were killed.

A third emulsion was formed by emulsifying 2 gallons of the same grade of kerosene as that used above with 1 gallon of soft soap dissolved in 2 gallons of water. Considerable difficulty was experienced in forming a stable emulsion with these ingredients.

This emulsion was diluted with water to such an extent that each 5 gallons of the diluted wash contained 1 gallon of kerosene. This proved fatal alike to the insects in all of their stages and also to their eggs.

It was also used in such proportions that each 7 gallons of the diluted wash contained 1 gallon of kerosene; this was fatal to all of the insects with the exception of a small number of the adult females with egg-masses; all of the eggs were killed.

Even the strongest solution, containing 1 gallon of kerosene in each 5 gallons of the diluted solution, produced no injurious effect either upon the trees or fruit; the trees experimented on were small orange trees about four years old.

Unlike the soap solutions, which penetrate the egg-masses and afterward harden, thus preventing the escape of the young insects after hatching out, the kerosene deprives the eggs of their vitality by penetrating first the egg-sacs and then the eggs themselves.

The cost of the kerosene (150°) is about 20 cents per gallon when purchased in large quantities.

TOBACCO.

Two pounds of tobacco leaves and stems were boiled in water until the strength of the tobacco had been extracted; the solution when cold was diluted with water and used in various proportions.

When used in the proportion of 1 pound of the tobacco to each 2 gallons of water, all of the insects were killed; about 3 per cent. of the eggs escaped injury.

When used in the proportion of 1 pound of the tobacco to each 4 gallons of the solution, it proved fatal to all of the insects with the exception of about 10 per cent. of the adult females with egg-masses; about 95 per cent. of the eggs were killed.

The strongest solution used, 1 pound of tobacco to each 2 gallons of water, produced no injurious effect upon the tree.

Several egg-masses were immersed in a solution containing a pound of tobacco to

1½ gallons of water, and this proved fatal to about one-half of the eggs. As this is out of all proportion as compared with the other experiments made by spraying the egg-masses upon the trees with the tobacco decoction of various strengths, I am led to believe that when the egg-masses are simply immersed in any solution, except when held in the solution for some time, they do not become so thoroughly saturated with it as when the latter is sprayed upon them; and I have proved beyond a doubt that a solution thrown upon the insects in the form of a fine spray will have a better effect than if thrown upon them in a coarser spray, just as a heavy fog or mist will more thoroughly wet a tree than a heavy shower of rain in large drops will do.

The cost of the tobacco at wholesale is about 10 cents per pound, but sometimes refuse tobacco can be obtained from cigar manufactories at from 1½ to 2 cents per pound.

SHEEP DIP.

This was the "Gold-leaf" brand, manufactured at Louisville, Ky., and said to be a pure extract of tobacco; it costs about $1.75 per gallon when purchased in large quantities.

It was diluted with water in various proportions, but even when used in the proportion of 1 gallon of the dip to 30 gallons of water it proved fatal to only about four-fifths of the young insects and one-fourth of the adult females with egg-masses, while the eggs were scarcely affected by it.

Several egg-masses were immersed in the pure dip, and none of the eggs thus treated hatched out.

TOBACCO SOAP.

Samples of this soap were received from the manufacturers. the Rose Manufacturing Company, of 17 South William street, New York City. The soap was first dissolved in hot water and afterward diluted with cold water.

One Pound of the Soap to nine Gallons of Water.—This proved fatal alike to the insects in all stages of development and also to their eggs.

One Pound of the Soap to twenty-one Gallons of Water.—This was fatal to all of the insects with the exception of about one-third of the adult females before secreting the egg-masses and a slightly larger number of those with egg-masses.

The cost of this soap has heretofore been 50 cents per pound, but I am informed by the agent here, Mr. J. B. Francisco, that the price of the soap has been recently reduced one-half.

VINEGAR.

A small branch of a lemon tree upon which were a number of Cottony Cushion-scales was immersed in pure grape vinegar, but it had very little effect upon the adult females and their eggs, and produced no perceptible injury to the leaves. It likewise had but little effect upon the insects when used in the proportion of 1 gallon of vinegar to 8 gallons of water in which 4 pints of soft soap had been dissolved.

PARIS GREEN.

One-half an Ounce of Paris green was thoroughly stirred into two Gallons of Water.—The whole was sprayed upon a small orange tree growing in the shade of some large eucalyptus trees. This proved alike fatal to the insects and the tree. In many places upon the tree the sap had exuded from the bark in considerable quantities, and remained adhering to the bark in the form of a brownish gum.

One-third of an Ounce of Paris green to two Gallons of Water.—This was sprayed upon all parts of a small orange tree, the greater part of it being sprayed upon the trunk and bases of the larger branches. In these places all of the insects were killed, but fully one-third of those situated upon the outer ends of the branches were not killed. In several different places the sap had exuded from some of the branches.

One-fourth of an Ounce of Paris green to two Gallons of Water.—This also killed all of the insects upon the trunk and bases of the larger branches, where the greater part of the solution had been sprayed, but only about one-half of the insects situated upon the outer ends of the branches were killed. This solution did not cause the sap to exude from any part of the tree.

One-fourth of an Ounce of Paris green to two Gallons of Water and one Pint of the Kerosene Emulsion.—The emulsion was formed by emulsifying 2 gallons of kerosene in 1 gallon of hot water in which had been dissolved half a pound of soap. A pint of this emulsion was diluted with 2 gallons of water, after which the Paris green was added; but it was impossible to keep the green incorporated in the solution, as it would rise to the surface the moment the stirring ceased. The effect of the solution upon the tree and insect was about the same as in the preceding experiment, with the exception that only about one-third of the insects situated upon the outer ends of the branches were killed.

REPORT UPON SUPPLEMENTARY EXPERIMENTS ON THE COTTONY CUSHION-SCALE; FOLLOWED BY A REPORT ON EXPERIMENTS ON THE RED SCALE.

BY ALBERT KOEBELE, *Special Agent.*

LETTER OF TRANSMITTAL.

ALAMEDA, CAL., *December* 1, 1886.

SIR: I herewith submit a report of continued experiments on the Cottony Cushion-scale (*Icerya purchasi*), made at Los Angeles, Cal., after the expiration of the appointment of D. W. Coquillett, with whom I worked previously, as directed by you in letter of January 28.

My warmest thanks are due to Mr. August Buschhaupt, of the Los Angeles Soap Company, for kindly assisting me in preparing the various soaps.

Very respectfully,

ALBERT KOEBELE.

Prof. C. V. RILEY,
U. S. Entomologist, Washington, D. C.

INTRODUCTORY.

The chief object of my work has been to find a wash as low in price as possible, and at the same time one which all the fruit-growers can prepare themselves. This, as is shown below, is not a difficult matter.

In March and April, while at work with Mr. Coquillett, and after witnessing various experiments, especially with soaps, I concluded that these, if tried in all their varieties, would prove good agents in destroying the scales, and that they also could be produced at a very reasonable cost. Up to this day, in my limited intercourse with orange-growers, I have seen nothing cheaper for killing the Cottony Cushion-scale.

It has always been a difficult matter to know just how much of the article used should be taken to a certain quantity of water to be effective on the scales and not injure the trees. Very often the spraying is done by inexperienced hands, and in such cases no good results can ever be expected even with the best washes. Naturally it will be used in stronger doses at the next operation, and the consequence will often be that there is more injury done than good. Experienced hands should always be engaged in this work to secure good results. I have myself witnessed a pair of inexpert operators, and was much amazed at the rapid progress of the work; yet when examining the trees a week later it was hard to find "dead scales."

No wash will be effective on *Icerya* unless penetrating the cottony mass, and for this purpose I found soap, or washes of soapy nature, the best. In most cases the majority of the young scales are found among the egg-masses, and unless these are destroyed the labor is of little value.

SOAP SOLUTIONS.

Almost any soap, if used in right quantity, will be destructive to both the eggs and the insects of *Icerya*, and, aside from resin compounds, will best penetrate the cottony mass. The egg-masses should always, and immediately after the tree has been sprayed, be completely penetrated by the wash. Unless this is the case the wash has not the effect of destroying everything. In some of the washes used, especially such as contained resin, the egg-masses, if not reached in the center, became so hard that rarely one of the young scales was able to leave its place of birth. Often one or more newly hatched scales will be found under the body of the mother scale at the point where the beak is inserted. Here, too, the mother scale exudes a little of the cottony substance, on which the body rests close to the bark. After light spraying and with weak wash this place remains dry and the young scales uninjured. Therefore a strong spray is of value, by which the scale is raised or somewhat removed from its firm place. Soaps 144 and 152, which I have made, will do as well at $\frac{1}{8}$ cent with a strong and thorough spraying as at $\frac{1}{4}$ cent by weak spray. Never have I observed eggs that were completely wetted by any of the washes used to hatch; in every instance they were destroyed.

For applying solutions there is nothing better than a cyclone nozzle for thorough work, especially if the exit hole be made considerably larger, to save time, and this is easily done.

The cyclone nozzle used in my experiments had been eaten out opposite the exit

hole to a depth of about 6^{mm}, and three additional plates of 2^{mm} thickness had been put on successively; a circular cavity formed in the chamber, and last the cap containing the outlet fell off. This also had been eaten nearly through. Not more than 1,000 gallons of wash had been sprayed with the nozzle. This may be largely due to the impure and sandy water used.

PREPARATION OF SOAP.

At the beginning of my work, in preparing whale-oil soap, I used chiefly Babbitt's potash or lye, which is sold in boxes of 4 dozen 1-pound cans, at from 9 to 10 cents per pound. To 1 pound of potash 2 gallons of water were added and placed over fire. After all the potash had been dissolved, 2 pints of fish-oil were added and contents cooked until the soap had formed; then 2 gallons more water were added and well mixed together. This formed a soft soap, and would, after cooling, readily mix with cold water.

The cost of this soap is about ½ cent per pint, and 2 pints are required to 1 gallon of water to destroy eggs and insects of *Icerya*. This would be 1 cent for 10 pints of wash. Fish-oil is sold generally at Los Angeles at about 32 cents per gallon, wholesale price.

Later, however, instead of using Babbitt's potash, I obtained caustic soda from the Los Angeles Soap Company. This is sold at wholesale by the same firm at 5 cents per pound, and it is equally as good as Babbitt's potash. To 1 pound of this caustic soda 3 pounds of grease, or part of that and resin to the full amount, should be taken, as will be shown in the experiments. Three pounds of tallow and resin to 1 pound of soda did much better work than did 4 of the first to 1 of the last. Tallow is sold by the same firm at 3 cents per pound and resin at 1½ cents, wholesale price. Almost any grease would answer in making soap, and much could be saved for this purpose which otherwise would not be made use of.

In making soap 152, 1 pound of caustic soda is dissolved in 1¼ gallons of water; then the 2 pounds of resin and 1 pound of tallow is dissolved in 1 quart of the lye; after the resin is all well dissolved by moderate heat the lye is added slowly, while cooking, under continued stirring. The mixture, if good, will become dark brown and thick. Should it become whitish and flocky (this is caused by too much and too strong lye), water should be added and it will become right again. This will make 22 pints of soap—for water should be added to make that amount after all the lye is in—at a cost of 11 cents, excluding fuel and labor in preparing it, which amount to but little, and will be sufficient for 44 gallons of wash if sprayed well. This is for *Icerya*. I would not recommend it stronger than ¼ cent for a gallon of the wash.

The same rule is to be observed in preparing soap No. 144. This has been tried also on two large trees by Messrs. Wolfskill and Craw, at ¼ cent per gallon of the wash. All eggs and insects were destroyed and the tree left in excellent condition.

In preparing these soaps the resin and tallow should never be dissolved without the additional lye. It will become so hot, that if a little lye is added a good part of the contents of the kettle will boil over. All this is avoided by adding the lye as said above, and the resin will dissolve the quicker.

In making tallow soap for experiment 77 the caustic soda should be dissolved in somewhat less water. One gallon is used. After the tallow and resin are dissolved together (in this soap it can be done without the lye) the lye should be added slowly while boiling, and afterward the required water added. Thirty-seven pints of soap were made in experiment 77 at ½ cent per pint. In using caustic soda the cost of same quantity—*i. e.*, 1 pound of soda, 5 cents; tallow, 2½ pounds, 7.5 cents; resin, ½ pound, 0.73 cent—would be only 13¼ cents; and in making 40 pints of soap this would be ⅓ cent per pint. One pint of soap to 7 pints of water would be sufficiently strong to kill the scales and their eggs.

A soap emulsion prepared cold is used extensively in and around Los Angeles. I have not seen any good results from it. If mixed with water free oil would float on the top, and trees treated with it would lose half their leaves and be arrested in growth for weeks. The fruit would be burned and marked from the excessive caustic it contains. I have seen several hundred trees in such condition in the Wolfskill orchard. The consistency of this particular mixture I could not learn. Never, and I have been assured so by experienced soap-men, can a proper soap be made except by cooking. Although my experiments 35 and 71 show good results, I would not recommend them.

RESIN COMPOUNDS.

These I found excellent for destroying *Icerya*, and the few experiments made on the Red Scale (*Aspidiotus aurantii*) showed promising results; yet further experi-

ments are required to be positive. The resin compound will penetrate the cottony mass of *Icerya* as well as, or even better than, soap. Yet its actions are slower, and if not used sufficiently strong, even if all the eggs are destroyed, some of the mother scales will not be killed by it, or if so, only after they have left a few fresh eggs, which will in due time hatch. Such eggs, if few, are brought forth loose, *i. e.*, without the usual protection of cottony exudation, and either drop to the ground or lie free above the destroyed egg-mass and under the dead mother. No doubt, many of these eggs never hatch, especially in hot weather.

It is quite different with eggs which are deposited by females that really survive treatment; the usual cottony mass is exuded, and thus the eggs are protected as usual and hatch always.

Its action on Red Scale is very promising, either mixed with soap or in simple emulsion, as experiments will show. Experiment 132, ½ pint of compound to 1 gallon of water, although costing only ⅛ cent per gallon of the wash, destroyed a large number of the scales; and a few days after application the covering became loose from the insect, so much so that some of them could be blown off and leave the insects exposed, affording an excellent opportunity for the mites, with which the tree was swarming, and which do not seem to be harmed by the wash.

A strong application of this emulsion will form a coating over everything on the tree, will exclude the insects from air for a few days, and will have entirely disappeared in a week in warm weather, as shown in experiment 134.

LYE SOLUTION.

A few experiments were made on hedges of young orange plants. Experiments 108–118 will show the results. While in every case the plant was more or less injured, the insects alone were killed, or part of them, and the contents of egg-sacs were not in the least affected, even with so strong an application that the plant was destroyed entirely.

BISULPHIDE OF CARBON.

A few experiments were made in fumigating with this article, but its action is too slow to be of value on large trees. Messrs. Wolfskill and Craw have made several experiments, and on trees of about 8 feet in diameter all the scales were destroyed in twenty-four hours. The trees were greatly benefited by it, as I am informed by these gentlemen.

KEROSENE EMULSION.

The cost of this article is too high for general use as a remedy for the Cottony Cushion-scale. An emulsion of "kerosene 1 gallon, soft soap ½ gallon, and water 1 gallon" (see experiment 41), cost about 24 cents for 2½ gallons of the emulsion. This is wholesale price. Three pints of this emulsion is required to 1 gallon of water to destroy both the *Icerya* and its eggs. This would be about 18 cents for 7 gallons of the wash.

In all the experiments made with this emulsion I have not seen the slightest injury done to the trees, as is the case with some of the soaps if used too strong.

Made in this way with soap, it penetrates the cottony mass more easily than if emulsified with some other substance.

Very good results were had with emulsion of petroleum. As this could be bought at from 6 to 7 cents per gallon in large quantities and combined with soap, it makes a reasonably cheap wash. The orange trees are left in an unsightly condition even for a month or six weeks after application, and it could therefore not be used on maturing fruit; yet if properly tried it may do good work on other scales on deciduous trees in the dormant state.

EXPERIMENTS.*

I now give in some detail an account of the more instructive of the experiments made, noting results in each case.

Experiment 18. Sheep-dip.

Sheep-dip, 1 pint; water, 15 pints. Applied July 9. On examination, July 16, found but few of the smaller scales killed; contents of egg-sacs not affected. Mr. Coquillett reported on other experiments with same mixture.

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*It will be noticed that the numbers of the experiments are not perfectly consecutive; but the omitted numbers will be found under the head of the "Red Scale", in the last section of the report.

Experiment 19. Emulsion of crude petroleum.

One gallon of crude petroleum; ½ gallon of soap of experiment 13 (consisting of whale-oil, 4 pints; potash, 1 pound; concentrated lye, 1 pound; and water, 7½ gallons), and ½ gallon of water. Applied May 4, and reported on by Mr. Coquillett. Soap and water were heated together first and petroleum added. This made a good emulsion after working for half an hour with hand pump, and remained stable for the next three weeks.

Emulsion, 1 pint; water, 1 gallon. Applied July 16. Will settle in drops on tree and not penetrate egg-masses. August 9, only a few of the smaller insects dead. Leaves spotted, but not injured.

Experiment 20. Emulsion of crude petroleum.

Emulsion, 2 pints; water, 1 gallon. Applied July 17. Will not penetrate egg-sac. August 9, found nearly all insects dead on trunk and large branches; young hatching numerously. The trunk and large limbs of tree remained free from scales for a long time after.

Experiment 21. Emulsion of crude petroleum and soap 13.

Emulsion, 1 pint; soap, 1 pint; water, 1 gallon. Applied July 17, and penetrated nearly all egg-masses. August 9, all insects killed and dry; a few of the eggs have hatched.

Experiment 22. Whale-oil soap and lime water.

Made of fish-oil, 3 pints; potash, 1 pound; water (in which 1 pound of slaked lime had stood for twenty-four hours*), 4 gallons.

Soap, ½ pint; water, 1 gallon. Applied July 31. Only a small part of scales killed and a few of the smaller egg-masses destroyed. Killed about half of the young Black Scale (*Lecanium oleæ*).

Experiment 23. Soap 22.

Soap, 1 pint; water, 1 gallon. Applied July 31. Will not penetrate all the larger egg-masses. August 8, a few of the mother scales still living; some young hatching. September 14, insects were not numerous.

Experiment 24. Soap 22.

Soap, 1½ pints; water, 1 gallon. Applied July 31 on lemon tree, with trunk and branches completely covered with scales. Penetrated all egg-masses. One hour after spraying, many dead Coleoptera, Hemiptera, and lace-wing flies were found on ground. August 8, occasionally a single living insect was found. August 23, insects few; very few young hatched; tree healthy and blooming.

Experiment 25. Whale-oil soap.

Made of fish oil, 9 pints; crude potash, 3 pounds; caustic soda, 1 pound; lime, 3 pounds; and water, 9½ gallons.

Soap, ½ pint; water, 1 gallon. Applied July 31. Will penetrate only smaller egg-masses. August 9, only a small part of scales killed. August 14, scales numerous; egg-masses covered with fungus.

Experiment 26. Soap 25.

Soap, 1 pint; water, 1 gallon. Applied July 31. Will penetrate all egg-masses. August 9, nearly all scales killed; a few newly hatched young on tree. September 14, scales few; tree in good condition.

Experiment 27. Soap 25.

Soap, 1½ pints; water, 1 gallon. Applied August 2. August 10, a few eggs found uninjured. August 14, some of the mother scales have produced fresh eggs before dying; others still living. September 14, scales quite numerous; tree healthy.

Experiment 28. Soap 25.

Soap, 2 pints; water, 1 gallon. Applied August 5 on lemon trees. Nearly all the scales were dry the following day. August 14, no living scales could be found; tree not injured.

* Whenever lime was used, only the clear water was taken after the lime had settled to the bottom.

Experiment 29. Soap 22.

Soap, 2 pints; water, 1 gallon. Applied August 6. August 10, found all scales and egg-masses hard; tree not injured. September 15, many scales have come on tree again; it is healthy and blooming.

Experiment 30. Soap 25 and crude carbolic acid.

Soap, 6 pints; crude carbolic acid, emulsified, ½ pound; water, 6 gallons. Applied August 7. Did not penetrate egg-masses well. August 23, living scales quite numerous.

Experiment 31. Soap 25 and petroleum emulsion.

Soap, 2 pints; emulsion, 1 pint; water, 3 gallons. Applied August 8. August 10, scales nearly all dead but not dry, having an inflated appearance. August 14, a few scales have recovered. September 14, tree clean; scales very few.

Experiment 32. Soap 25. Petroleum emulsion.

Soap, 2 pints; emulsion, 1 pint; water, 2 gallons. Applied August 9. Destroyed all scales and eggs. September 14, occasionally one scale on branches only; none on stem. Tree healthy; fruit not injured or spotted.

Experiment 34. Soap 25. Petroleum emulsion.

Soap, 3 pints; emulsion, 1 pint; water, 2 gallons. Applied August 9. Found scales and egg-masses hardened the following day and many dead insects on ground. September 14, very few scales; stem and large branches entirely free; tree healthy and growing.

Experiment 35. Soap made cold. Soap emulsion.

One pound of potash was dissolved in 1 quart of water; 2 pints of fish-oil made lukewarm, and the lye slowly added under continued stirring; then ½ gallon of water, in which 1 pound of slaked lime had been, was added. After two days water was added to make 36 pints, and in a week it had become an emulsion or imperfect soap. One pint of this (costing 1 cent) to 1 gallon of water. Applied August 11. Will penetrate all egg-masses well. August 14, found all scales and eggs destroyed. August 17, black sticky drops remained on fruit and leaves had begun to drop. September 14, occasionally one young scale; black drops had disappeared from fruit, not leaving any mark. About one-quarter of the leaves have fallen.

Experiment 36. Emulsion 35.

Heated emulsion to cooking-point; then took 1 pint to 1 gallon of water. This did not penetrate egg-masses well, and many of the larger remained dry inside. Destroyed all of the scales, but some of the eggs hatched and young became numerous. Many leaves dropped.

Experiment 37. Whale-oil soap.

Made of potash, 1 pound; fish-oil, 2 pints; and water to make 36 pints of soap, costing ½ cent per pint.

Soap, 2 pints; water, 1 gallon. Applied August 13. This penetrated all egg-masses well, and all the scales were found dead the next day. August 17, scales and egg-masses hard.

Experiment 38. Soap 37.

Soap, 1 pint; water, 1 gallon. Applied August 13. Will not penetrate egg-masses well. About half of the eggs and scales killed.

Experiment 39. Soap 37. Petroleum emulsion.

Soap, 5 pints; emulsion, 1 pint; water, 42 pints. Applied August 13. Tree well sprayed. All the scales were found dead the next day. Only a few of the eggs hatched, but scales were numerous again September 14.

Experiment 40. Soap 37. Petroleum emulsion.

Soap, 5 pints; emulsion, 1 pint; water, 4 gallons. Applied August 16. On the 18th all the scales killed; egg-masses hard. August 23, a few scales on stem again. September 14, scales increasing, especially on stem; tree and fruit not injured or discolored.

Experiment 41. Kerosene emulsion.

Kerosene, 1 gallon; soap, 37½ gallons; water, 1 gallon. Soap and water heated and all worked together for half an hour with pump. This formed a cream-white emulsion and became as thick as cream on cooling.

One pint of this emulsion to 1 gallon of water. Applied August 16. Did not penetrate egg-masses; killed only a small part of young scales. September 14, tree full of scales.

Experiment 42. Kerosene emulsion 41.

Emulsion, 2 pints; water, 1 gallon. Applied August 16. Did not penetrate egg-masses well. Found next day about half of the eggs destroyed, also about half of the scales were dead; several dead Coleoptera on ground. August 23, a few of the scales still living; eggs hatching. September 14, a few of the mother scales still living; young hatching numerously.

Experiment 43. Kerosene emulsion 41; soap 37.

Emulsion, 1 pint; soap, 1 pint; water, 1 gallon. Applied August 16. Tree well sprayed; penetrated nearly all the egg-masses. August 23, a few insects still living. September 14, scales numerous; Black Scale (*L. oleæ*) not all dead.

Experiment 44. Kerosene emulsion 41; soap 37.

Emulsion, 1 pint; soap, 3 pints; water, 4 gallons. Applied August 16. Tree sprayed well, and nearly all egg-masses were found wet. August 18, about half of the scales dry, the others still soft but inflated; some of the egg-masses dry in center. August 23, young hatching occasionally. September 14, scales numerous again.

Experiment 45. Kerosene emulsion 41; soap 37.

Emulsion, 1 pint; soap, 3 pints; water, 2 gallons. Applied August 17. Had penetrated all egg-masses well after spraying; found 3 dead larvæ of *Tortrix* on stem, destroyed by wash. August 23, occasionally one living insect; no young hatching. September 14, few insects on branches, but stem full.

Experiment 46. Kerosene emulsion 41; soap 37.

Emulsion, 1 pint; soap, 5 pints; water, 6 gallons. Applied August 17 on lemon tree. Did not penetrate egg-masses well; killed one-half of the eggs and three-fourths of the scales. In a short time the tree was full again.

Experiment 47. Kerosene emulsion 41; soap 37.

Emulsion, 1 pint; soap, 5 pints; water, 4 gallons. Applied August 18. Occasionally one of the mother scales survived, but very few young hatched.

Experiment 51. Kerosene emulsion 41.

Emulsion, 3 pints; water, 1 gallon. Applied August 25. Tree full of *Icerya* and Red Scales. Penetrated all egg-masses well; killed eggs and insects of *Icerya*. Only a few young of Red Scale hatched; old all destroyed.

Experiment 63. Tar soap.

Made of fish-oil, 2 pints; pine tar, 1 pint; potash, 1 pound; water, 4 gallons.

Soap, 1 pint; water, 1 gallon. Applied August 31. September 10, some of the mother insects still living and producing fresh eggs. September 18, all insects covered with fungus; some of the mother scales living; young hatching.

Experiment 64. Tar soap 63.

Soap, 2 pints; water, 1 gallon. Applied August 31. Penetrated all egg-masses well, and all scales and eggs were destroyed; tree not injured.

Experiment 65. Tar soap 63.

Soap, ½ pint; water, 1 gallon. Applied August 31. Killed only a small part of young scales and small egg-masses.

Experiment 68. Tobacco soap.

Made of tobacco, ½ pound; fish-oil, 2 pints; potash, 1 pound; and water to make 42 pints of soap.*

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*The tobacco is placed in a bag and well cooked with part of the lye, and this is added after the soap is complete.

Soap, 1 pint; water, 1 gallon. Applied September 2. Penetrated only smaller egg-masses well. September 6, occasionally one scale living; no young as yet have hatched. September 11, scales still dying; large females, although living, yet soft and sickly; noticed many walking down on trunk of tree. No newly hatched young could be found. November 4, scales few; tree in good condition.

Experiment 69. Tobacco soap 68.

Soap, 1½ pint; water, 1 gallon. Applied September 2. Will not penetrate egg-masses well. November 6, no living insects found. November 11, occasionally one moving scale; nearly everything dry. September 14, a few of the mother scales are depositing fresh eggs, but without cottony mass, lying exposed. November 4, scales very few; tree healthy.

Experiment 70. Tobacco soap 68.

Soap, 2 pints; water, 1 gallon. Applied September 2. Will penetrate all egg-masses if sprayed well. Pump broke and tree was not sprayed well. September 6, all eggs destroyed and nearly all the insects; a few were observed leaving the tree. September 18, quite a number of living scales on tree; some still dying. November 4, scales few; tree healthy.

Experiment 71. Soap emulsion 35.

Another trial of this emulsion was made; contents same as in 35. The mixture was stirred every day and used on the tenth day.

One pint of this emulsion to 1 gallon of water. Applied September 2 on large tree; 10 gallons of the wash used. Penetrated all egg-masses. September 6, all eggs and scales destroyed. Result about the same as in 25, but not quite as many leaves fell. October 7, tree remarkably clean, growing well; fruit not marked.

Experiment 74. Whale-oil soap.

Made of whale-oil, 3 pints; potash, 1 pound; water to make 40 pints of soap; costing about ½ cent per pint. This was not as perfect as when only 2 pints of oil were used.

Soap, 1 pint; water, 1 gallon. Applied September 6. Result, about three-fourths of scales and eggs killed.

Experiment 75. Soap 74.

Soap, 1½ pints; water, 1 gallon. Applied September 6. Result: Will destroy eggs and scales, but also tips and budding leaves or tender shoots; the older leaves did not fall.

Experiment 76. Soap 74.

Soap, 2 pints; water, 1 gallon. Applied September 6. Killed scales and eggs; result on tree about the same as in 75.

Experiment 77. Tallow soap.

Made of tallow, 2½ pounds; resin, ½ pound; potash, 1 pound; and water to make 34 pints of soap; costing ½ cent per pint.

Soap, 1 pint; water, 1 gallon. Applied September 9. Wash will penetrate all egg-masses well. September 10, eggs and insects destroyed; nearly everything hard. Nothing escaped this wash, and the tree was not in the slightest injured or arrested in its growth.

Experiment 78. Soap 77.

Soap, 1½ pints; water, 1 gallon. Applied September 9. Killed scales and eggs; tree not injured.

Experiment 79. Soap 77.

Soap, ½ pint; water, 1 gallon. Applied warm, September 9. Penetrated only smaller egg-masses well. About half of the scales and eggs destroyed.

Experiment 84. Soap of fish-oil, tobacco, and resin.

Made of fish-oil, 2 pints; resin, ½ pound; tobacco, ½ pound; potash, 1 pound; and water, 3 gallons.

Soap, ½ pint; water, 1 gallon. Applied September 11. Many of the scales survived, and only small part of the eggs were destroyed.

Experiment 85. Soap 84.

Soap, 1 pint; water, 1 gallon. Applied September 11. September 18, some of the scales hardened and others became inflated. One of the mother scales deposited 6 more eggs before dying and one of the young hatched. On September 22 all had

hardened. October 5, no young scales; tree covered with fungus. November 4, fungus loose; scales very few; tree in good condition.

Experiment 86. Soap 84.

Soap, 1½ pints; water, 1 gallon. Applied September 11. On the 18th some of the insects were still dying. On the 30th all were hard. October 5, tree full of fungus.

Experiment 87. Soap 77.

Soap, ½ pint; water, 1 gallon. Applied September 11. Tree well sprayed, and most of the egg-masses were penetrated by wash. Result: Nearly all the eggs destroyed; only a few mother scales survived and produced fresh eggs.

Experiment 88. Resin soap.

Made of resin, 2 pounds; tallow, 1 pound; potash, 1 pound; and water to make 20 pints of soap; costing ¾ cent per pint.

Soap, ½ pint; water, 1 gallon. Applied September 13. Penetrated all egg-masses well. September 18, some of the scales began to dry up; no fresh eggs. September 22, all dead, but not hard. October 4, occasionally one young scale; tree in fine condition.

Experiment 89. Soap 88.

Soap, 1 pint; water, 1 gallon. Applied September 13. The scales were all dead on the 22d, but not hard. October 5, scales and eggs destroyed; tree in good condition.

Experiment 90. Soap 88.

Soap, 1½ pints; water, 1 gallon. Applied September 13. Destroyed scales and eggs, although they were not hard on the 22d. October 5, no living scales; tree in good condition.

Experiment 92. Tobacco soap.

Made of tobacco, ½ pound; tallow, 1½ pounds; resin, 1½ pounds; potash, 1 pound; and water to make 40 pints of soap; costing ½ cent per pint.

Soap, ½ pint; water, 1 gallon. Applied September 15. Tree well sprayed. Result: Nearly all the scales and eggs destroyed; scales die very slowly; some Hemiptera and Coccinellids found dead on ground.

Experiment 93. Soap 92.

Soap, ¾ pint; water, 1 gallon. Applied September 15. September 17, all eggs and scales seem to be destroyed. September 22, insects not yet all dry, but dead; tree in very good condition. Wash sufficiently effective.

Experiment 94. Soap 92.

Soap, 1 pint; water, 1 gallon. Applied September 15. Penetrated all egg-masses well and destroyed everything. September 22, scales not hardened; nothing living.

Experiment 99. Resin soap.

Made of resin, 3 pounds; tallow, 1 pound; potash, 1 pound; and water to make 32 pints of soap; costing ½ cent per pint.

Soap, ½ pint; water, 1 gallon. Applied September 20 on large and dirty tree full of fungus, almost covering some of the egg-masses. Nearly all the eggs were destroyed. Some of the mother scales recovered and produced fresh eggs.

Experiment 100. Soap 99.

Soap, ¾ pint; water, 1 gallon. Applied September 20. Had penetrated all egg-masses after spraying. September 22, nearly all scales killed. October 12, occasionally one living scale.

Experiment 101. Soap 99.

Soap, 1 pint; water, 1 gallon. Applied September 22. Some of the mother scales were still living on the 24th, yet all had died on September 30, but were not dry. November 2, tree nearly clean of scales. It was also thickly infested with Red Scale, but all these were killed.

Experiment 102. Soap 77 and lime water.

One pound of slaked lime in 20 pints of water. After the water became clear ½ pint of this was taken with ½ pint of soap to 7½ pints of pure water. Applied September 24. Result: All eggs destroyed and scales all dead after six days, although a few fresh eggs were left. Tree not injured. The trees were very thoroughly sprayed. The result would not have been so good with a light spraying.

Experiment 103. Tobacco soap 92; lime water 102.

Soap, ½ pint; lime water, ½ pint; water, 7½ pints. Applied September 24. Result not as good as in 102, as a number of mother scales survived. October 5, found a number of living scales, fresh eggs, and newly hatched young.

Experiment 104. Resin soap 99; lime water 102.

Soap ½ pint; lime water, ½ pint; water, 7½ pints. Applied September 24. Result as in 102; very few living scales October 4.

Experiment 108. Babbitt's potash lye.

Potash, 1 pound; water, 2 gallons. Applied September 29. Result; Killed all insects, but did not injure contents of egg-sacs; nearly all leaves dropped; tender shoots killed and bark burned.

Experiment 109. Babbitt's potash lye.

Potash, 1 pound; water, 4 gallons. Applied September 29. Result: Killed scales; did not injure contents of egg-sacs; tips of plant destroyed; leaves badly burned in spots.

Experiment 110. Babbitt's potash lye.

Potash, 1 pound; water, 6 gallons. Applied September 29. Killed all free young and nearly all of the mother scales, contents of egg-sacs uninjured; tips of plant broken off; leaves spotted in parts.

Experiment 111. Babbitt's potash lye.

Potash, 1 pound; water, 8 gallons. Applied September 29. Only part of scales killed; contents of egg-sacs uninjured; tips of plant injured; leaves spotted in parts.

Experiment 112. Babbitt's concentrated lye.

Concentrated lye, 1 pound; water, 2 gallons. Applied September 29. Scales all killed; contents of egg-sacs uninjured; all leaves dropped; tips of plant killed; bark burned in parts.

Experiment 113. Babbitt's concentrated lye.

Concentrated lye, 1 pound; water, 4 gallons. Applied September 29. Killed all scales, not injuring contents of egg-sacs; tips of plant killed; one-third of the leaves dropped, remainder all spotted.

Experiment 114. Gillett's concentrated lye.

Concentrated lye, 1 pound; water, 1 gallon. Applied September 29. Scales all killed; contents of egg-sacs uninjured; plant entirely killed.

Experiment 115. Gillett's concentrated lye.

Concentrated lye, 1 pound; water, 2 gallons. Applied September 29. Killed all scales; contents of egg-sacs uninjured. Some of the shoots killed near ground; only a few leaves remaining near the ground.

Experiment 116. Gillett's concentrated lye.

Concentrated lye, 1 pound; water, 4 gallons. Applied September 29. Killed scales, not injuring contents of egg-sacs; tips of plant destroyed; leaves spotted.

Experiment 117. Gillett's concentrated lye.

Concentrated lye, 1 pound; water, 6 gallons. Applied September 29. About half of the mother scales survived; contents of egg-sacs not injured; tips of plants destroyed.

Experiment 118. Gillett's concentrated lye.

Concentrated lye, 1 pound; water, 12 gallons. Applied September 29. Only a few of the scales killed; contents of egg-sacs not injured; tips of plants destroyed.

Experiment 119. Lime water.

One pound of slacked lime in 20 pints of water. Applied September 29. Killed only a few of the scales; all became completely covered by fungus. This had disappeared again November 4, and insects were in good condition.

Experiment 120. Resin soap.

Made of resin, 3 pounds; tallow, 1 pound; caustic soda, 1 pound; and water to make 25 pints of soap; costing ½ cent per pint.

Soap, ½ pint; water, 1 gallon. Applied October 4 on large tree. Three gallons of wash were required; only lightly sprayed. Scales died slowly; mother scales left a few fresh eggs. October 14, occasionally one young scale found.

[*All experiments after* 120 *only lightly sprayed.*]

Experiment 121. Soap 120.

Soap, 1 pint; water, 3 gallons. Applied October 4. Will penetrate egg-masses in about 3 minutes. A few of the scales recovered and produced fresh eggs.

Experiment 122. Resin compound.

Made of resin, 4 pounds; soda ash (pure carbonate of soda), 1 pound; water to make 36 pints of compound; costing 11 cents.

Compound, 1 pint; water, 3 gallons. Applied October 4. Only penetrated smaller egg-masses. Killed only a few of the smaller scales, and a few eggs only were destroyed.

Experiment 123. Resin compound 122.

Compound, 1 pint; water, 2 gallons. Applied October 4; did not penetrate egg-masses well, and only about half of them were destroyed. Many mother scales survived.

Experiment 124. Resin compound 122.

Compound, 1 pint; water, 1½ gallons. Applied October 4. Penetrated all but the largest egg-masses well. Some of the mother scales and some eggs escaped.

Experiment 125. Resin compound 122.

Compound, 1 pint; water, 1 gallon. Applied October 4. Penetrated all egg-masses well. A few of the mother scales survived and produced fresh eggs. None of the eggs sprayed have hatched.

Experiment 126. Resin soap 120.

Soap, 1 pint; water, 4 gallons. Applied October 4. Penetrated only smaller egg-masses. Killed most of the smaller scales, but only a few of the smaller egg-masses were destroyed.

Experiment 129. Resin compound.

Made of resin, 4 pounds; common washing soda (carbonate of soda), 3 pounds; water to make 36 pints of compound; costing ⅓ cent per pint.

Compound, 1 pint; water, 2 gallons. Applied October 7. Will penetrate only smaller egg-masses. A few young scales only and small portion of eggs destroyed.

Experiment 130. Resin compound 129.

Compound, 1 pint; water, 1½ gallons. Applied October 7. Did not penetrate larger egg-masses. Destroyed all smaller ones and a few of the mother scales. November 4, scales numerous on tree.

Experiment 131. Resin compound 129.

Compound, 1 pint; water, 1 gallon. Applied October 7. Penetrated all egg-masses well on slight spraying. October 11, a few mother scales, which were protected by fungus, still living. October 14, all scales dead; occasionally a few eggs left among fungus.

Experiment 134. Resin compound 129.

Half compound and half water, to see effect on plants. Applied October 7. Will penetrate egg-masses instantly on application. All scales and egg-masses hard on examination two days after; plant as if varnished and sticky. This had disappeared on October 13, leaving the plant in excellent condition, not a leaf having dropped.

Experiment 135. Resin compound.

Made of resin, 4 pounds; caustic soda, 1 pound; and water to make 33 pints of compound; costing ½ cent per pint.

Compound, 1 pint; water, 2 gallons. Applied October 8. Will penetrate only smaller egg-masses on light spraying; many of the mother scales survived and young were numerous November 4.

Experiment 136. Resin compound 135.

Compound, 1 pint; water, 1½ gallons. Applied October 8. Did not penetrate larger egg-masses well on light spraying; many of the mother scales survived, and October 25 occasionally a single young could be found.

Experiment 137. Resin compound 135.

Compound, 1 pint; water, 1 gallon. Applied October 8. Will penetrate all egg-masses well on light spraying in about two minutes. October 11, some of the mother scales still living; but no fresh eggs could be observed. October 14, scales all dead. November 4, no young have hatched; tree not injured.

Experiment 138. Resin soap.

Made of resin, 2 pounds; tallow, 2 pounds; caustic soda, 1 pound; and water to make 28 pints of soap; costing ½ cent per pint.

Soap, 1 pint; water, 2 gallons. Applied October 14. Did not penetrate egg-masses; killed most of smaller scales, but had no effect on contents of egg-sacs.

Experiment 139. Soap 138.

Soap, 1 pint; water, 1½ gallon. Applied October 14. Will penetrate only the smaller egg-masses well. October 16, all scales are dead. November 4, no young had hatched.

Experiment 140. Soap 138.

Soap, 1 pint; water, 7 pints. Applied October 14. Will penetrate all egg-masses well on light spraying. October 16, no living scales could be found.

Experiment 141. Resin compound.

Made of resin, 4 pounds; washing soda, 3 pounds; and water to make 24 pints of compound. This is somewhat thick, and will not so readily mix with water as 129, especially after cooling.

Compound, 1 pint; water, 1½ gallon. Applied October 15. Penetrated all egg-masses and destroyed them; some of the mother scales produced fresh eggs before dying. Found no living scales October 25.

Experiment 142. Resin compound 141.

Compound, 1 pint; water, 1 gallon. Applied October 15. Will penetrate all egg-masses well in about 2 minutes with light spraying. Found no living scales October 16.

Experiment 143. Resin compound 141.

Compound, 2 pints; water, 1½ gallons. Applied October 15. Will penetrate immediately. October 16, nothing living. October 28, scales still soft, but rotten. November 4, no living scales on tree, which was left in fine condition, with the wash still visible.

Experiment 144. Resin soap.

Made of resin, 1½ pounds; tallow, 1½ pounds; caustic soda, 1 pound; and water to make 23½ pints of soap; costing ½ cent per pint.

Soap, 1 pint; water, 2 gallons. Applied October 18. Penetrated all but a few large egg-masses well with light spraying. October 23, all scales dead; no fresh eggs. October 28, found occasionally one newly hatched larva.

Experiment 145. Soap 144.

Soap, 1 pint; water, 1½ gallons. Applied October 18. Destroyed all eggs and insects.

Experiment 146. Soap 144.

Soap, 1 pint; water, 1 gallon. Applied October 18. All egg-masses well penetrated after spraying; destroyed all eggs and scales; not the slightest injury done to the tree.

Experiment 152. Resin soap.

Made of resin, 2 pounds; tallow, 1 pound; caustic soda, 1 pound; and water to make 25 pints of soap; costing 11 cents.

Soap, 1 pint; water, 2 gallons. Applied October 27. Will penetrate nearly all egg-masses with light spraying. November 1, all scales dead; no fresh eggs left; a few of the old eggs will hatch.

Experiment 153. Soap 152.

Soap, 1 pint; water, 1½ gallons. Applied October 27. Will penetrate all egg-masses well in about two minutes after a light spraying. Next day some of the mother scales were still living, but all were dead October 30, and no fresh eggs were left. November 4, nothing living; fungus loosening and coming off; tree in fine condition.

Experiment 157. Resin compound.

Made of resin, 30 pounds; caustic soda, 3 pounds; and water to make 230 gallons of wash; at a cost of 60 cents. Sprayed by Mr. Alexander Craw, and reported in letter of November 22. White Scale when well saturated die, but when only lightly sprayed form new wax. Black Scale all dead. As a wash for Black Scale in the fall and winter it will be admirable, but for the most thorough work only 180 gallons of water should be taken.

Experiments on Fumigation with Bisulphide of Carbon.

Experiment 1.—September 29. One and a half fluid ounces in 1-pound tin can were set on the ground near young shoots of orange, and a 50-gallon cask placed over this for three hours. After removing cask only half of the carbon had evaporated; scales seemed to be dead. On examining next day found all of them living.

Experiment 2.—September 29. Poured three-fourths fluid ounce into bottom of cask; placed this over young plants at 3 p. m.; left until 1 p. m. next day. All the insects were found dead, and had changed their color to a light hyacinth red. October 4, leaves began to drop. October 7, nearly all eggs had changed to straw color. About three-fourths of the leaves dropped, and the plant had not recovered November 1.

Experiment 3.—September 30. One and a half fluid ounces in 1-pound tin can set under cask and left for 20 hours. Destroyed all scales and eggs. About one-third of the leaves dropped.

Experiment 4.—October 1. One and a half fluid ounces poured into cask and placed over plants for 3 hours. Killed all scales and eggs. No leaves dropped, and the plant has not in the least been injured.

Experiment 5.—October 14. Made on tree about 7 feet high and 5 inches in diameter, under tent. Two fluid ounces in shallow tin pan placed in middle of tree from 11 a. m. until 3 p. m. Destroyed all the scales except those on a few of the lowest branches, where the eggs also remained uninjured. Tree not injured; no leaves dropped.

Experiment 6.—October 22. On tree about 8 feet in diameter, under tent. Six fluid ounces in shallow tin pan set in middle of tree at 3.30 p. m. and left until 6.30 p. m. Had no effect whatever on scales.

EXPERIMENTS ON RED SCALE (*Aspidiotus aurantii*).

Experiment 33. Soap 25.

Soap, 2 pints; water, 1 gallon. Applied August 5. August 14, nearly all scales killed; a few mother scales with eggs and young living. October 5, only a few newly formed scales could be found.

Experiment 48. Kerosene emulsion and soap 37.

Kerosene emulsion, 1 pint; soap, 5 pints; water, 4 gallons. Applied August 18. Tree full of scales; some of the branches already destroyed. August 23, many young scales have hatched; only part of large scales dead. September 24, about one-fifth of old scales living; many young on tree.

Experiment 49. Soap 37.

Soap, 3 pints; water, 1 gallon. Applied August 18. Tree thickly infested with *Icerya* and Red Scales. August 23, scales nearly all dead and dry; a few young. September 24, a few of the old scales still living; occasionally a young larva found; tree in good condition.

Experiment 50. Soap 37.

Soap, 3 pints; water, 1 gallon. Applied August 18. Tree thickly infested with scales; half of the branches killed. August 23, about half the leaves have dropped. September 6, leaves have ceased dropping; tree recovering; occasionally one young scale found. September 18, tree pushing out new shoots. November 4, tree growing vigorously; young scales very few.

Experiment 52. Kerosene emulsion 41.

Emulsion, 4 pints; water, 1 gallon. Applied August 25 on tree infested with *Icerya* and Red Scale. August 28, *Icerya* all destroyed, Red Scales apparently so. September 24, a few gravid females still living; occasionally a single newly formed scale.

Experiment 53. Kerosene emulsion 41; soap 37.

Emulsion, 2 pints; soap, 1 pint; water, 1 gallon. Applied August 25. August 28, many young scales forming. September 7, about 10 per cent. of old scales living; many young forming. November 4, tree swarming with scales.

Experiment 54. Kerosene emulsion 41; soap 37.

Emulsion, 1 pint; soap, 2 pints; water, 1 gallon; Applied August 25. September 7, found two mother scales living; young forming quite numerously. October 5, tree full of young scales.

Experiment 55. Kerosene emulsion 41; soap 37.

Emulsion, 3 pints; soap, 1 pint; water, 1 gallon. Applied August 25 on small and faded tree. September 7, leaves nearly all off; many young scales forming. September 22, branches all dead; many young scales on stem; no living adults.

Experiment 56. Kerosene emulsion 41; soap 37.

Emulsion, 1 pint; soap, 3 pints; water, 1 gallon. Applied August 25. August 28, found a few living young under mother scale. September 7, many newly formed scales. September 24, old scales all dead; young quite numerous. October 5, scales very few; tree doing well.

Experiment 57. Kerosene emulsion 41.

Emulsion, 5 pints; water, 1 gallon. Applied August 31 on small and sickly tree. September 7, no living old scales; only two living young could be found. September 24, leaves all off; scales few. October 5, tree pushing out new shoots on stem; some branches still living. November 4, tree growing; scales few.

Experiment 58. Kerosene emulsion 41.

Emulsion, 6 pints; water, 1 gallon. Applied August 31. Tree lightly sprayed. September 22, a few of the mother scales still living; young forming quite numerously. October 5, no living old scales; young few; tree in good condition.

Experiment 59. Kerosene emulsion 41.

Half emulsion and half water. Applied August 31. Tree sickly and thickly infested with *Icerya* and Red Scale; also many Black Scales; many branches already dead. On very careful examination September 7 found one gravid female still living and some young scales forming. September 24, tree bringing forth new shoots on stem; young scales quite numerous. October 5, upper part of tree all dead, although growing well below; scales few.

Experiment 60. Soap 37.

Soap, 4 pints; water, 1 gallon. Applied August 31 on small and faded tree thickly infested with *Icerya* and Red Scale. September 7, found two moving young; leaves remaining only on lower branches. September 24, tree nearly dead; trunk again covered with *Icerya*. October 5, tree shooting out below; scales few.

Experiment 61. Soap 37.

Soap, 6 pints; water, 1 gallon. Applied August 31 on small and withered tree full of *Icerya*, Red and Black Scales. September 7, all scales destroyed; occasionally one young forming. September 24, a few young scales; tree shooting out again. October 5, hardly any Red Scales, yet the tree is covered again with Cottony Cushion-scale.

Experiment 62. Soap 37.

Half soap and half water. Applied August 31. September 7, scales all destroyed; on careful examination only one moving young could be found; only a few leaves had dropped. October 5, tree shooting out everywhere. November 4, tree almost free from scales and growing vigorously.

Experiment 66. Tar soap 63.

Soap, 2 pints; water, 1 gallon. Applied September 2 on tree that had been nearly killed by the scales. September 6, scales not all killed; young hatching numerously. October 5, some of the older scales still living; young numerous; tree nearly dead.

Experiment 67. Tar soap 63.

Soap, 4 pints; water, 1 gallon. Applied September 2 on large tree covered with scales. September 22, found only a very few young; old scales all dead; tree not

injured by wash. November 4, on careful examination only a few young scales could be found.

Experiment 72. Tobacco soap 68.

Soap, 2 pints; water, 1 gallon. Applied September 3 on thickly infested and nearly dead tree. September 22, only about three-fourths of the scales killed. October 5, living scales of all sizes present, but not abundant.

Experiment 73. Tobacco soap 68.

Soap, 4 pints; water, 1 gallon. Applied September 3 on small and sickly tree; some of the branches already killed by scales. September 7, scales not yet all dead; tips of young shoots somewhat injured, and a few of the old leaves dropping. September 22, no living scales; tree recovering. October 5, not a single scale could be found on most careful examination; tree in fine condition, growing vigorously.

Experiment 82. Soap 77.

Soap, ½ pint; water, 1 gallon. Applied September 9. September 18, only a small part of the scales killed. October 5, about four-fifths of the scales dead.

Experiment 83. Soap 77.

Soap, 1½ pints; water, 1 gallon. Applied September 9. September 18, all scales killed; not the slightest injury done to tree by wash. October 5, not a living scale could be found; tree in fine condition.

Experiment 95. Tobacco soap 92.

Soap, 1 pint; water, 1 gallon. Applied September 18. October 5, scales nearly all killed; young hatching quite abundantly. October 28, no living adults; young numerous.

Experiment 96. Tobacco soap 92.

Soap, 2 pints; water, 1 gallon. Applied September 18. October 5, a few gravid females living; a few young hatching. October 28, only young scales could be found, but these were quite numerous; tree in good condition.

Experiment 97. Tobacco soap 92.

Soap, 3 pints; water, 1 gallon. Applied September 18. September 24, tree not injured. October 11, all scales dry; no young could be found.

Experiment 98. Resin soap 88.

Soap, 1 pint; water, 1 gallon. Applied September 18. September 24, scales dying slowly; blossoms and budding leaves not injured. October 5, occasionally one gravid female living; very few young.

Experiment 105. Resin soap 99.

Soap, 1 pint; water, 1 gallon. Applied September 27. October 5, scales apparently all killed; found two newly-formed young. October 11, old scales all dead; young quite numerous.

Experiment 106. Resin soap 99.

Soap, 2 pints; water, 1 gallon. Applied September 27. October 5, scales apparently all dead; have changed in color; a few leaves dropping. October 11, scales all killed; not a single young scale could be found; tree not injured.

Experiment 107. Resin soap 99.

Soap, 4 pints; water, 1 gallon. Applied September 27. October 5, all scales discolored; not yet dry; leaves dropping. October 7, leaves still dropping. October 11, leaves have ceased dropping; all scales dead; no young. October 28, not a living scale could be found; tree in good condition.

Experiment 127. Resin soap 120.

Soap, 1 pint; water, 1 gallon. Applied October 4. October 11, all young and nearly all old scales dry; found two moving young. October 16, scales all dead. November 4, occasionally one young scale.

Experiment 128. Resin soap 120.

Soap, 2 pints; water, 1 gallon. Applied October 4. October 11, all scales dead and dry; tree not in the least injured. On the most careful examination, October

16 and 22, and November 1 and 4, I was unable to find any living scales; tree was growing nicely at last-mentioned date.

Experiment 132. Resin compound 129.

Compound, ½ pint; water, 1 gallon. Applied October 7. October 12, all young scales dry; old scales all loose and changed in color. October 15, old scales seem to be dead, yet not dry; found many dead young under mother scales. November 4, about three-fourths of the scales killed; they became firm again on the leaves after two weeks; mites very numerous.

Experiment 133. Resin compound 129.

Compound, 1 pint; water, 1 gallon. Applied October 7. October 12, nearly all scales dead and dry and changed in color; all the scales on insects that were not dry loose and easily removed; mites very numerous. October 15, no living scales could be found. October 22, found three newly formed scales. November 4, very few young and no living old scales could be found; tree not in the least injured; no leaves dropped.

Experiment 147. Resin soap 144.

Soap, 1 pint; water, 2 gallons. Applied October 23. October 28, found several moving young and a few newly formed scales. November 4, a few gravid females still living; young increasing.

Experiment 148. Resin soap 144.

Soap, 1 pint; water, 1 gallon. Applied October 23. October 28, all scales killed; found one moving young. November 4, occasionally one young; no old scales could be found.

Experiment 149. Resin soap 144.

Soap, 2 pints; water, 1 gallon. Applied October 23. October 28, budding leaves destroyed; old leaves dropping. November 1, a few leaves still dropping; tree had been in poor condition, and this experiment was made chiefly to see result of wash.

Experiment 154. Resin soap 152.

Soap, 1 pint; water, 1½ gallons. Applied October 27. November 3, nearly all scales killed; some of the mother scales not yet dry.

Experiment 155. Resin soap 152.

Soap, 1 pint; water, 1 gallon. Applied October 27. November 3, found all scales dead; no young could be found.

Experiment 156. Resin compound 141.

Compound, 2 pints; water, 1 gallon. Applied November 2. November 4, all scales have changed on tree as well as on fruit. Mr. Craw examined the tree again for me September 22, and he writes that all the young scales were dead, but many of the old scales were living.

Experiments 154 and 155 were made at a late date, and the results perhaps would vary a little if examined a month later; yet the soap will do excellent work on *Icerya* at ½ cent per gallon with strong spray. I believe that the wash of experiment 154 would not kill all the Red Scales. The soap of experiment 120 is but little different, yet this destroyed all the Red Scales, at ½ cent per gallon of the wash, as sprayed by Messrs. Wolfskill and Craw.

In regard to experiment 156, Mr. Craw's statement is contrary to my expectations. Although I had at the time of spraying a poor pump, and the tree had not been sprayed well, yet the spray would miss the young as well as the old scales.

I examined tree of Experiment 133 often and carefully. In eight days nearly all the scales were dry. This is the same wash as that of 156, but costs only ½ cent for 9 pints of the wash, while in experiment 156 the cost would be 1 cent for 10 pints of the wash.

Resin compound is a good remedy in destroying *Icerya* and its eggs, and further experiments will show the value of it on Red Scale.

The best results so far on the Red Scale were had with soaps 120, 144, and 152, and these last two are also best for *Icerya*.

The fact that there are nearly always, even with the strongest washes, young scales found afterward may be largely due to the fact that the ground below thickly infested trees is always covered with infested leaves which have dropped, and naturally most of the young will crawl back upon the tree again after the spraying. They will also come from surrounding plants.

INSECTS AFFECTING SMALL GRAINS AND GRASSES.

By F. M. WEBSTER, *Special Agent.*

LETTER OF TRANSMITTAL.

LA FAYETTE, IND., *November 2,* 1886.

SIR: I herewith transmit my annual report for the current year, containing a continuation of my studies of the Wheat Isosoma, and a new pest, the Companion Wheat-fly; notes on *Meromyza americana*, and some insects affecting Barley; a list of insects frequenting or depredating upon Buckwheat; notes upon the destruction of timothy meadows by the Glassy Cut-worm; and two enemies of the White Clover.

As usual, I am under obligation to yourself and assistants for the determination of material, and numberless other favors.

Respectfully submitted.

F. M. WEBSTER,
Special Agent.

Dr. C. V. RILEY,
Entomologist.

INSECTS AFFECTING FALL WHEAT.

THE WHEAT-STRAW ISOSOMA.

(*Isosoma tritici* Riley.)

Up to June of the present year matters remained very much as they were left in my previous report, so far as obtaining any additional facts relative to the habits of this species is concerned. Straws, in which *grande* only had oviposited, failed to furnish adults of any sort, and straws taken from the fields gave only wingless females of *tritici*, which, as usual with those reared in mid-winter, refused to oviposit on wheat plants grown and kept indoors for that purpose. On returning from the South in April, however, we found a limited number of these *tritici*, which had emerged much later, probably in March, alive in the breeding-cages, and at once transferred them to young wheat plants grown and kept continually under cover, in a corner of our garden, at least three-fourths of a mile from any field of either wheat, rye, or barley. This was on the 12th of April.

From this time forward until the grain and straw were fully ripened, early the following July, the utmost caution was observed in keeping the plants thoroughly protected from outside insects, and, with the exception of a single Tipulid, which appeared during spring, no insects whatever were at any time observed within the inclosure except the *Isosoma*.

On the 2d of June, fifty-one days after the *tritici* had been placed in the inclosure, a female of *grande* was observed in the act of ovipositing in the now nearly full-grown straw, and within the next few days several others were noticed similarly occupied, placing their eggs not only in the upper joint, but in the one below also. Previous to this, and, in fact, since the 21st of May, the latter species had been observed continually in the fields, and the belated appearance of these in the inclosure is perhaps due to the fact that their progenitors, the *tritici*, were of the last to emerge in the spring. Absence from home for two months previous to the date of their removal from the breeding-cage to the young wheat made it impossible to secure them earlier, as it was difficult to get enough then living to carry on the experiments, the numerous dead in the cage indicating that the species had been emerging for some time.

As before stated, the *tritici* placed in the inclosure were all of them females. Neither could any males be found among those that had previously died, and, moreover, all of the *grande* were females apparently, as all that were observed at all in the inclosure were ovipositing. Hence the males of either form, if there are any, are still unknown to me.*

A winged form of *Isosoma*, seemingly intermediate between *tritici* and *grande*, was taken with the latter in considerable numbers about Bloomington, Ill., during May, 1884, and has since been found in the vicinity of La Fayette, Ind., in both grain fields and grass lands, but in too limited numbers to permit of successful

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* As shown on page 544, we have been more successful in this respect than has Mr. Webster, and three males of *tritici* were bred in January, 1886.—C. V. R.

rearing in confinement, and hence what affinities it may have with other forms or species is not known.

A small form of *hordei* also occurred about La Fayette during the latter part of May, 1885, on blue grass and timothy, growing up intermixed, and also to a very limited extent on wheat; but this also refused to oviposit in the latter in the breeding-cages, and disappeared from the field of both grain and grass altogether in a few days.

The same locality was repeatedly swept over during the present season, but no *hordei* could be found. *Grande* were, however, obtained in considerable numbers from grass lands, but the most careful search failed to reveal any indication that they emerged from these grasses or that they oviposit in them.

It may be proper to state here that in the three years during which I have had these Isosomas under observation they have never been observed ovipositing in chess, nor has an instance been noticed where the straws of this grass have been affected by them. This discrimination on the part of these insects, whereby the stools of wheat are prevented from heading, while those of the grass continue to flourish, may perhaps in part account for the unexpected preponderance of the latter during some seasons, a phenomenon which so sorely taxes the science of the unbotanical farmer.

There is, however, a species of larva infesting the stems of timothy from the latter part of July to the following spring whose method of work is very similar to that of the wheat-straw worms, but which nevertheless belongs to a different order of insects. It is probably the larva of a species of *Languria*,* and may readily be distinguished by the form of the head, by the more slender and less smooth body, and by the presence of well-developed legs on the thoracic segments.

THE AMERICAN MEROMYZA.

(*Meromyza americana* Fitch.)

Full-grown larvæ of this species were observed by us on June 18 of the present year in a field of rye near Kentland, Newton County, Indiana, and we bred adults from straw grown near La Fayette about July 21, and again from volunteer wheat in the same field from which the straw had been taken from September 3 to 21. A previous examination of this field made August 31 had revealed the fact that the volunteer wheat plants growing upon a space 1 foot square contained 11 puparia, 1 empty case, and 1 two-thirds grown larva.

On October 5 we found adults in great numbers (and also adults of a parasite, *Cœlinius meromyzæ* Forbes) engaged in ovipositing on wheat in a field sown September 22, and on going to another field, which had been sown much earlier, we found adults there also, but in less numbers, although the former field had been sown on oat stubble, while the latter field had last produced a crop of wheat.

In view of these observations and the results of your own breedings from volunteer wheat sent you from Oxford, Ind., on September 6, 1884, there seems little reason to doubt the existence of a third brood of flies, originating, largely at least, in volunteer grain, and emerging therefrom during the month of September.

As we have elsewhere shown,† the observations of Fitch, Riley, Lintner, Forbes, and ourself in no case have indicated that a third brood was improbable, but in some instances strongly presage its existence.

THE COMPANION WHEAT-FLY.

Oscinis (?) sp.

During the latter part of June, 1884, while examining wheat straws in which the larvæ of *Meromyza americana* were at work, we often found several smaller larvæ, also dipterous, and so closely associated with the former that we at first suspected them of being parasites. They were almost invariably found among the juicy mass of substance that had been displaced by their larger consort.

Securing a supply of affected straws, we cut from each a section about 3 inches

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*Specimens of this larva were forwarded to us by Mr. Webster, but the adult beetle was not bred. The larva was indistinguishable from that of *Languria mozardi*, described by Professor Comstock in the Annual Report of this Department for 1879 under the popular name of "The Clover-stem Borer," as he had reared it from stems of Red Clover at Washington. Mr. Webster's larvæ probably belong to this species, which is figured on Plate I, Fig. 6, of the report just cited, and described on page 199.—C. V. R.

† Bulletin No. 9, Purdue University, issued October, 1886.

long, including the upper joint, but excluding the head, and placed them in a breeding jar. The result was, when the adult *Meromyza* emerged from these sections, July 18 to 23, there appeared among them quite a number of a much smaller black species, closely resembling those of the genus *Oscinis*, but, however, being quite distinct.

Early in the following September larvæ, seemingly like those observed in the straw, were found feeding within the stems of young volunteer wheat plants, and later the same thing was observed to destroy young plants in a field of early sown wheat.

From this volunteer wheat adult flies of the species now under consideration emerged from September 7 to October 1. The present season they began to emerge August 30, in both cases being the most numerous about the 10th of September. We have also reared adults from larvæ in wheat sown during the last week of August, these emerging as late as the 3d of October. The adults are common in wheat fields after about September 10 until the 1st of October, and hover about the young plants, doubtless for the purpose of ovipositing, as they are often observed pairing.

We have never observed them during late fall or early spring. They are sometimes attacked by a fungous parasite very similar to, if not identical with, that attacking the house-fly.

The larvæ are much smaller than those of *Meromyza*, but in a general way resemble them in form and color, particularly when the latter are only partly grown.

The puparia are, however, very different, being only about 2.5^{mm} long and 0.8^{mm} broad. The color is never like that of *Meromyza*, being at first of a yellowish-white, with tinge of green, but later changing to a uniform brown. They are readily distinguished from those of the Hessian fly by being cylindrical and by the segments being well defined.

From the foregoing it will be observed that, so far as we have been able to study the species, its cycle is exactly parallel with that of the *Meromyza*, and besides, there is a strong probability that while in young wheat the larvæ work independently, in the full-grown straws, where the tissue is too tough for their less rugged mouth parts, they become the mess-mates of their stronger consort, and feed from the vegetable juices by which it is surrounded. It is this characteristic that suggested the common appellation selected.

The damage done to young wheat in the fall by this species must be considerable, the credit thereof falling upon the *Meromyza*, as the effect of the two larvæ is exactly the same.

INSECTS AFFECTING BARLEY.

On account of the limited area sown, we have had but little opportunity to study the insect enemies of this cereal, but it is extremely probable that the species do not differ greatly from those depredating upon the closely allied grains—wheat and rye.

The two species here mentioned were observed in a small plot of this grain on the University experiment farm, which had produced nothing but barley for the last five or six years.

THE WHITE GRUB.

(*Lachnosterna fusca* Fröhl.)

These well-known depredators were observed during the present season engaged in cutting off the roots of the full-grown and fully-headed grain. As late as the 28th of June they were causing whole stools of the straw to wither and dry up before the kernels had filled.

THE BARLEY ROOT-LOUSE.

(*Schizoneura* sp.)

Both winged and apterous individuals were found clustering on the roots of barley in this same plot on the 12th of June, 1885, and at that time seemed to be doing considerable injury, but we were unable to secure an above-ground form.

The present season we found the same species in the same place but several days earlier, and watched them continuously until the 15th of July, when a few individuals might still be found upon the roots, although the grain was fully matured. Again we failed to secure an aereal form, although the grain was kept under careful inspection until harvest, nor could we rear any such in a breeding-cage, to which we had transferred infested barley plants.

In the fields the lice were all attended by ants, as usual, and, when placed in the breeding-cage without their protectors, seemed to be well-nigh helpless.

THE GRAIN APHIS.

(*Siphonophora avenæ* Fab.)

This species was observed infesting the heads of barley in considerable numbers, and, when the grain was fully ripe and the winged adults ready to forsake the barley heads, we placed some of them in cages in which growing timothy, blue-grass, and red-top had been transplanted, with the hopes of learning where the species passed the summer or until the young wheat appeared in the fall. The grasses were kept alive, but the insects died, and no trace of a following generation was observed.

INSECTS FREQUENTING OR DEPREDATING UPON BUCKWHEAT.

So many reports of the aversion of insects for this plant are going the rounds of the press, nearly all of which are unaccompanied by generally accepted authority, that some exact data relative to the matter seems very desirable. It was with a view of obtaining this information that, under Dr. Riley's instructions, we began a series of observations, selecting as a basis one of the experiment plots of the University farm, which for the past five years has grown nothing but buckwheat, thereby eliminating at the start any insects that might have been attracted by a previous crop of grain or grass and remained over in either the adult or adolescent stages.

As the object of the observations was a twofold one, *i. e.*, to learn both the repulsive and the direct and indirect attractive properties of the growing plant, what may at first appear to be overexactness will at once be seen to be quite essential, as the occurrence of an insect but once or twice during several weeks is strongly indicative of a repugnance for the locality.

Observations began as soon as the plants were well above the surface of the ground, and, until they were high enough to sweep with an insect-net, consisted of careful inspection only, but later the entire plot was swept over at intervals of a few days and a record kept of all captures. As some species visit the plants at one time of day and others at another, the time of sweeping was varied, in order to preclude the possibility of any escaping notice in that way. These observations were carried on until frost destroyed the plants.

In the table the symbol "A" signifies abundant; "C," common. Where only very few examples occurred their number is indicated numerically. Unless otherwise stated the adult stage is intended, and where a * follows the name of insect the larval state only is intended; if a †, the pupal. When these follow the other symbols, A or C, it is to be understood that all states occur, adults preponderating. If they precede the letter, all states occurred in numbers indicated. Thus A * †, adults abundant, larvæ and pupæ; * † C, all stages common.

List of insects.

Insects.	Aug. 4, p. m.	Aug. 17, p. m.	Aug. 18, a. m.	Aug. 20, 9.20 a. m.	Aug. 24, 4 p. m.	Aug. 28, 4 p. m.	Aug. 31, 10.20 a. m.	Sept. 3, 1.20 p. m.	Sept. 7, 10 a. m.	Sept. 11, 3.30 p. m.	Sept. 14, 9.15 a. m.	Sept. 20, 12 m.	Sept. 25, 2.30 p. m.	Oct. 1, 2 p. m.
Apis mellifica Linn	....	....	....	C	....	....	A	....	A	...	A	A	....	....
Bombus sp	....	....	....	....	....	....	....	....	1	....	2	....	....	....
Cerceris compactus Cr	1	....	....	....	....	....	....	....	....	....	....	....	....	....
Halictus flavipes (Fabr.)	....	C	....	....	....	....	2	....	....	1	1	....	....	....
Halictus sp. ? (No. 19)	....	C	A	A	....	....	C	....	C	....	....	....	....	....
Sphex pennsylvanicus Linn	1	....	....	....	....	....	1	....	1	....	2	....	....	....
Ammophila uruaria Dahlb	....	....	....	....	1	....	....	....	....	2	....	1	....	1
Pompilus sp	....	....	....	....	....	....	....	....	1	....	....	....	....	....
Tiphia (near) *inornata* Say	....	....	....	....	....	....	1	....	....	....	....	....	....	....
Tiphia sp. ?	....	C	C	C	....	C	1	....	....	....	....	2	....	....
Myzine harnata Say	....	1	....	2	....	....	2	....	A	....	1	3	....	....
Mutilla (near) *fenestrata* St. F	....	1	....	....	....	....	....	....	....	....	1	....	....	....
Lasius flavus	C	C	C	C	C	C	C	....	C	A	A	A	....	2
Perilampus (near) *hyalinus* Say	....	....	....	2	C	2	A	A	A	A	A	A	C	1
Formica schaufussii	3	C	C	C	C	C	A	3	A	A	A	C	....	3
Caliopsis andreniformis Say	....	C	....	1	....	....	1	....	....	C	....	....	....	....
Cynipid sp. ?	....	....	....	....	C	C	A	....	....	C	C	....	....	....
Agathis sp. ?	....	1	....	....	....	....	....	....	....	....	2	....	....	....
Mesograpta marginata Say	....	....	....	....	....	....	....	....	1	....	C	....	....	....
Pieris protodice Bd	....	....	....	2	....	....	2	1	C	C	A	A	C	....
Colias eurytheme Bd	....	....	....	....	....	....	....	....	C	....	1	2	....	....
Danais archippus Fab	....	....	....	....	....	....	....	....	1	....	....	....	....	....
Pyrameis atalanta Linn	....	....	....	....	....	....	....	....	1	....	....	1	....	....
Pyrameis cardui Linn	....	....	....	....	....	....	....	....	1	....	....	....	....	....
Deilephila lineata Fab.*	....	....	....	....	....	....	1	....	3	....	1	2	2	....

List of insects—Continued.

Insects.	Aug. 4, p. m.	Aug. 17, p. m.	Aug. 18, a. m.	Aug. 20, 9.20 a. m.	Aug. 24, 4 p. m.	Aug. 28, 4 p. m.	Aug. 31, 10.20 a. m.	Sept. 3, 1.20 p. m.	Sept. 7, 10 a. m.	Sept. 11, 3.30 p. m.	Sept. 14, 9.15 a. m.	Sept. 20, 12 m.	Sept. 25, 2.30 p. m.	Oct. 1, 2 p. m.
Acronycta oblinita A. & S.*											1			
Acontia erastoides Guen				2	C	A	C	C	C	C	C	C		
Geometrid larva					1									
Crambus (near) *fuscicostella* Zell. (No. 13)	1													
Dichœlia sulphureana Clem.*					2	1	1	1						
Eurycreon rantalis Guen			3	C	A	A	A	A	A	C	C	C	2	
Cicindela punctulata Fab	C	C	C	C	C	C	C	C	C	C	3	1	1	1
Harpalus pennsylvanicus Dej								1	1					
Tachyporus brunneus Fab				1		1		1		C				
Sylvanus advena Waltl										1				
Corticaria pumilis Mels				2					C	C	1	C	C	C
Hippodamia convergens Guen								1						
Hippodamia parenthesis Say									1		2			
Cycloneda sanguinea Linn							1				1			
Coccinella 9-notata Hb							1				1			
Chauliognathus pennsylvanicus Först				2	C	C	C	C	A	C	C	C	1	
Ditemnus bidentatus Say			1											
Cyphon variabilis Thunb											1			1
Bruchus obsoletus Say							1				1	2	1	
Colaspis brunnea Fab	A	A	A	C		1		2	1		1			
Doryphora 10-lineata Say			1											
Chrysomela suturalis Fab												2		
Diabrotica 12-punctata Oliv					2			1	1	2	2	2	1	
Diabrotica vittata Fab												1		
Diabrotica longicornis Say			C	C	A	A	A	A	A	A	A	A	C	2
Disonycha punctigera Lec									C			2		
Longitarsus testaceus Lec											2			
Phyllotreta vittata Fab					2	1								
Systena frontalis Fab						1								
Systena blanda Mels				1							1			
Crepidodera atriventris Mels									1					
Chætocnema confinis Cr		C	A	A		A	A	1	C		1	C	C	1
Mordella octopunctata Fab		1												
Epicauta vittata Fab	A	C	A	C	C		1	2	1					
Epicauta lemniscata Fab	A	A	A	C	2	1		2	1		1			
Epicauta cinerea Först	3													
Epicauta pennsylvanica De G					1									
Centrinus picumnus Hort														2
Sphenophorus parvulus Gyll		1												
Sciara sp. ? (No. 31)				1	C	C	A	A	A	A	C	C	C	
Bibio sp. ? (No. 82)									2	2				
Anthrax sp. ?	A	C	1											
Sparnopolinus sp. (No. 14)	1	C						2		C				
Stratiomyia sp. ? (No. 87)									1					
Oscinis sp. ? (No. 26)		1		3	2	C	C	C	3	C	C	C	C	
Oscinis sp. ? (No. 64)					C	C	A			C	C			
Chlorops sp. ? (No. 65)				C	A	A	A	A	A	A	A	A	A	C
Meromyza americana Fitch							1	C	C	1	2	C	C	1
Syritta pipiens Macq											C	C	2	
Oncomyia sp. ? (No. 89)										1				
Chelonus sericeus Say											1			
Aphis sp. ? (Root-form)							C	C	C	C	C			
Dactylopius n. sp. ?							C							
Jassus inimicus Say			C	C	C	C	C	C	C	C	1	C	3	2
Macropsis venatus Uhl			C	C	C	C	C	C		C	1	C		
Actualis calva Say (var.)										1				
Diedrocephala mollipes Say											1	1		
Euschistus servus Say									1				1	
Corizus lateralis Say				1			1			1	2	C	C	
Blissus leucopterus Say							C	1						
Geocoris limbatus Stäl	1			1	C	1								
Lygus pratensis Linn		C	A	C	A	A	A	A*	A*	A*†	*†A	A*†	A*†	A
Calocoris rapidus Say						2	C	C	C	C	C*	C*	*†C	1
Plagiognathus obscurus Uhl		1	1	C	C	C	1		C	2	1	1		
Plagiognathus sp. ? (No. 24)		1	3			1	2		C	A	C		2	
Agalliastes sanvis Reuter		1	1		2			C	3	C	C			
Triphleps insidiosus Say		A	A	A	A	A	A	A	A	A*	A*	A*†	C*†	2
Corius ferus Linn					2	C		1		1	2	C	C*	
Acholla multispinosa De G								2	1		1	1	1	
Coleothrips 3-fasciata Fitch				C	C	C	C	A	A	A	C	3	2	
Œcanthus niveus						1	3					2		
Orchelimum vulgare Harr						1		1		1				
Gryllus abbreviatus	C	C	C	C	C	C	C	C	C	C	C	C	3	1
Melanoplus femur-rubrum Harr	A	A	A	A	A	A	A	C	C	C	C	C	C	C
Œdipoda carolina Linn							1		2	1			1	
Crysopa externa ?							2	1	C		2	C	C	
Smynthurus sp. ?						3		C	A	A	A	C		

The Hymenoptera, as a rule, occurred most abundantly during the forenoon. Of the *Lepidoptera*, *Acontia* and *Eurycreon* were the most abundant. *Dichelia* was reared to the adult, but the *Geometrid* larva died, and it is very doubtful if this was really one of its food-plants.

The rarity of *Carabidæ* is quite suggestive as being in accordance with the lack of earth-inhabiting larvæ, and likewise the dearth of *Coccinellidæ* might be traced to the lack of *Aphididæ*. *Bruchus obsoletus* doubtless wandered from a plot of beans near by. *Colaspis brunnea* fed upon the buds. The lack of *Doryphora* was strongly indicative of disgust for the plant, as the adjoining plot was planted to potatoes, which they destroyed, and migrated to other localities, but studiously avoided the buckwheat. The same was true of *Epicauta*, excepting the *vittata* species, which fed upon the foliage quite freely. *Diabrotica longicornis* was one of the most abundant insects, and fed upon the blossoms. *Aphis* sp.? and the *Dactylopius* were both found upon the roots. The spasmodic occurrence of *Blissus leucopterus* has the same signification as the single occurrence of *Doryphora*. *Lygus pratensis* was one of the most abundant species, and at the time of the last two observations it outnumbered all others ten to one. *Melanoplus femur-rubrum* seriously injured some of the young plants, but only along the margins. *Gryllus abbreviatus* cut off the plants and dragged them into its burrows, but only for about the first week after they came up. Larvæ of *Chrysopa* were quite numerous during August and September. Possibly these were of the same species as the adults. The *Anthrax* emerged from pupæ in the soil in considerable numbers during the early part of August.

Besides these, Dr. Riley (First Mo. Rep., p. 79) states that the larvæ of *Agrotis clandestina* and (Third Mo. Rep., p. 109) *Laphygma frugiperda* (*Prodenia autumnalis*) affect this plant, as also (Seventh Mo. Rep., p. 159) *Melanoplus spretus*. Dr. Cyrus Thomas (Sixth Ill. Rep., p. 171) thinks *Gastrophysa polygoni* might attack the plant, but we found nothing of the species in this case. In Riley's Seventh Mo. Rep., p. 43, a correspondent states that *Blissus leucopterus* did not affect his corn where buckwheat was sown among it. *Deiliphila lineata* (larva) is recorded as feeding upon this plant by Dr. Riley in Third Mo. Rep., p. 141.

INSECTS AFFECTING TIMOTHY.

THE GLASSY CUT-WORM.

(*Hadena devastatrix*, Brace.)

On June 29 of the present season Mr. J. G. Kingsbury, of the *Indiana Farmer*, called our attention to some rumors which had reached him relative to the depredations of some kind of worm in the timothy meadows about Richmond, Wayne County, Indiana, and we immediately wrote Mr. J. C. Ratliff, of Richmond, from whom, on the 12th of July, we received a reply fully corroborating the reports given us by Mr. Kingsbury.

On the 15th, in accordance with instructions from Mr. Howard, entomologist in charge, we visited the infested fields, three in number, situated to the northwest of the city, one on the grounds of the insane asylum, another about a half a mile north of this on the farm of Mr. Kreets, and the third on the farm of Mrs. Thompson, perhaps 2 miles farther to the northwest.

The field on the grounds of the asylum, of which about 15 acres were totally destroyed, had been plowed and planted with corn after the ravages had ceased, but the other two fields, of which about 15 and 20 acres, respectively, had been destroyed, remained intact. A critical examination of the affected portions of these two fields revealed the fact that even where every vestige of timothy had been destroyed red clover remained untouched, and a decided preference had been evinced for low, damp localities.

In the Thompson field chrysalids were found quite abundantly within a couple of inches of the surface; and with them, in almost equal numbers, were the larvæ of *Hadena devastatrix*, some of which were already in frail earthen cells, preparatory to pupating, all of these last being of a dingy-white color, with yellow heads. Interspersed among the *Hadena* larvæ were a very few of *Nephelodes violans*. In the Kreet field both chrysalids and larvæ were much less abundant, although the destruction had been equally complete. Here also the *Nephelodes* larvæ were found, but in a still smaller ratio as compared with those of the *Hadena*.

To settle any doubt which might arise as to which of the two species of larvæ were the authors of the destruction, we questioned the owners of the fields very closely, as well as the employés on the two farms, but all stated that the striped larvæ had

never been numerous, and that it was the white ones with brown heads ("about half way between a worm and a grub," as they expressed it) which did the injury. In fact, an aged and intelligent gentleman, Mr. Vinnedge Russell, as soon as he learned of our arrival, went to the Thompson field and brought us therefrom a number of *Hadena* larvæ, remarking that the striped worms had occurred with them, but only in very limited numbers, and that those brought were the depredators.

From what we were able to learn, the effect of these worms was noticed for the first about the middle of May, and they continued to carry on their work for about three weeks, after which they appeared to do no injury, and the dried remains of the young grass seemed to attest to the statement, as in no case were any withered or dead clumps observed. The destruction appeared to lie solely in the amputation of the small roots, neither the bulb nor the blade having been ravaged, and we were informed that the worms were in no case observed feeding above ground, but invariably below the surface.

Although no such outbreak of these larvæ in meadows had been previously recorded, this habit of feeding below ground, and upon the roots of grasses was noticed long ago by Dr. Riley, who found that the larvæ would bury themselves in the earth, and feed in this manner from grass roots, although other food was provided them.*

That the *Hadena* larvæ, in both the Thompson and Kreet fields, originated in each case in excessive numbers throughout only a very limited area, and that they gradually extended their domains as the food-supply became exhausted, was very evident. In the Kreet field, which was very low, flat, and damp, the depredations began in the southwest corner, the worms gradually working eastward parallel with the highway, which was carefully avoided, and a margin of grass six to ten yards wide was left almost untouched, while they pushed farther and farther to the northward for a considerable distance, destroying every vestige of timothy, gradually seeming to exhaust themselves near the northern and eastern boundaries of the field.

In the Thompson field they originated in the northwestern portion, along a low, wide ravine, traveling eastward, following a narrow ravine near the northern boundary, a tributary of the former, nearly across the field, while elsewhere along the line of origin they did not extend their depredations more than about one-third as far, as that direction brought them upon the higher ground.

We were informed that while a few worms had been observed working upon the higher grounds in this field little damage had been done there, but as the tributary ravine reached high ground there had been a tendency to spread out at right angles, those on the south side being, as it were, thrown across the path of those worms proceeding east from the place of origin. As in the Kreet field, the boundary between the totally destroyed portion and the uninjured was irregular and poorly defined, a gradual fading of one into the other.

In this field larvæ and pupæ were found in considerable abundance, although many of the former did not appear in a healthy condition, and many of the latter had a blackened look, and some others had evidently been destroyed by some natural enemy. But in the Kreet field the case seemed different, for here it required considerable labor to obtain either larvæ or pupæ, even in limited numbers, and many of these were affected as in the Thompson field. Dead larvæ were found in the earth, stretched at nearly full length, rigid, and with a parasitic fungus, a species of *Isaria*, growing from between the thoracic segments, but more frequently from the neck, after the manner of *Torrubia* from the white grub, only that in this case they affect the upper as well as the under part. This was also observed to attack the larvæ of *Nephelodes violans*.

On July 17 a goodly number of larvæ and pupæ were secured from both fields and placed in earth in tin boxes. Returning home on the 19th, these boxes were at once opened, and found to be literally swarming with a species of *Pteromalus*. The larvæ and pupæ were placed in separate cages, the *Pteromalus* continuing to appear in that containing pupæ for several days afterward. Later there appeared from these pupæ a single individual of *Ichneumon jucundus*, a species of *Tachina*, and also a species of *Phora*. This last, however, was doubtless a scavenger and not a parasite.

The first moth appeared from the pupæ on the 22d, and the first appeared from the larvæ on August 11. All moths obtained were *Hadena devastatrix*, but not over 10 per cent. of the adolescent individuals developed to adults.

Had the appearance of the Glassy Cut-worms been more general, in such numbers as in the vicinity of Richmond, the loss would have been very serious; as it

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*First Report Insects of Missouri, p. 83, 1868. Report Commissioner of Agriculture, 1884, p. 297.

was, Mr. Ratliff, who is a crop correspondent of this Department, estimated the damage to the three fields at about $1,000.

We have not been able to learn of any such depredations elsewhere, and Messrs. A. W. Butler, of Brookville; Stephen Gardner, of Cottage Grove; S. S. Merrifield, of Connersville; and D. E. Hoffman, of Winchester, all located in Wayne and adjacent counties, have written us disclaiming all knowledge of any similar ravages.

While we were on the ground too late in the season to observe the working of these worms or carefully study their movements, both the appearance of the affected fields at that time and the information obtained were strongly indicative of a slow, migratory habit. Mr. Kreet stated that he had several times observed the worms collected in deep holes in the earth, from which they appeared to be endeavoring to escape. All of this is very suggestive of preventing the progress of the worms by ditching, or even plowing a deep furrow across their course, and destroying them as they accumulate in the bottom, as with the Army Worm.

We again visited the locality on October 30. The Kreet field had been plowed in the mean time, and was now covered with a luxuriant growth of wheat. The Thompson field remained as we had left it in July, but neither there nor in other meadows could we find any young Cut-worms of this species, although a few of other species were observed. We dug up the earth to a depth of several inches in places where it seemed most probable that they would occur, but found none.

We observed a considerable number of carnivorous larvæ in the Thompson field, and these, quite likely, aided in sustaining the check given the worms by the parasites of the spring brood.*

THE GRAIN SPHENOPHORUS.

(*Sphenophorus parvulus* Gyll.)

During the latter part of July of the present year the larvæ of this species were observed burrowing in the bulbs of timothy, their method of work not differing materially from what it was in wheat, as described in our last year's report, excepting that the bulb, being much larger than a straw, enabled the larva to attain to nearly or quite full growth before leaving it to pupate. Several larvæ were often found infesting a single stool. Pupæ were also found in the earth about these stools.

While examining the roots of timothy in meadows about Richmond, Wayne County, Indiana, on October 30, we found an adult of *Sphenophorus sculptilis* Uhl. in the midst of a mass of eaten bulbs, these last resembling in every particular those which had been destroyed by *S. parvulus*.

INSECTS AFFECTING WHITE CLOVER.

THE FLAVESCENT CLOVER WEEVIL.

(*Sitones flavescens* Allard.)

Early in the month of October, 1885, the foliage of White Clover (*Trifolium repens* L.) on the University grounds was found to be seriously injured by some insect depredator, and a plot of Alsike (*T. hybridum*) was likewise attacked, while Red Clover (*T. pratensis*) escaped with very little injury, even though growing up promiscuously among both of the former varieties.

This injury to the leaves of clover was of two patterns, one consisting of a circular disk extracted from the center and the other a more or less hemispherical portion taken from the margin, and, while there was never more than one circular space eaten from the same leaf, there might be several of the marginal pattern, or the two might be combined, thereby leaving only the leaf-stalk and bases of the mid-veins.

Careful search failed to reveal any insect about the injured plants in sufficient numbers to arouse suspicion, except a small, yellowish-brown curculio, *Sitones flavescens* Allard, an imported species, injurious to clover in Europe, but not previously known as such in America, although Dr. Riley had some years ago † directed atten-

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* One of these species of larvæ was that of an Elater, probably *Drasterius dorsalis* Say. The larvæ of this genus are known to be carnivorous, and we have observed this species destroying the larvæ of *Crambus zeellus* Fern., and also those of an undetermined species of *Macrops* which burrows in the roots of common plantain (*Plantago major* L.).—C. V. R.

† *American Naturalist*, Vol. XV, p. 751, and Report Commissioner Agriculture 1881, p. 177.

tion to its native habits, and Dr. Lintner had placed it in his list of possible enemies of the clover plant in New York.*

Dr. Le Conte† gives the species as inhabiting the Atlantic States in abundance, especially near the sea-shore, and states that the American race differs from the European by the color of the scales, being more rusty and less gray. We have for years found it plentifully here in the West, while Dr. E. R. Boardman reports both the beetles and their work in Stark County, Illinois, and Mr. Charles N. Ainslie, Rochester, Minn., makes a similar statement.

The beetles are rather timid, and, on being disturbed, drop to the ground and seek refuge among leaves and rubbish, and it was only after considerable patient watching that they were observed in the act of feeding upon the leaves. This they do by simply moving the head and thorax, the body remaining stationary, the circular disk being cut when the leaf is still folded, the two halves facing each other, the beetles eating through the back at the mid-vein. The half disk thus extracted from the two makes a full disk when the leaf is fully unfolded.

On October 17 a number of the beetles, confined alive in a small vial, deposited a number of eggs therein; and on the 25th of same month other adults, which had been placed in a breeding-cage with clover plants selected and transplanted from a locality where the leaves had not been injured, also oviposited, dropping their eggs about promiscuously, some being on the leaves, others scattered about on the surface of the soil, and one stuck to the side of the cage.

The eggs are nearly white, with a very slight tinge of yellow; slightly elongate, ovate, being a trifle less than 0.4^{mm} broad and a little more than 0.4^{mm} in length; not acuminated or depressed.

In a temperature of 65° F. these eggs hatched in about 48 hours after being deposited, the young larvæ at once disappearing. A few days later they could be found feeding upon the fresh lateral shoots, or even the softer parts of the main stem under the bases of the leaf stalks. The entire plant upon which the larvæ were confined withered and died within a few weeks, although it was kept well watered and under favorable conditions for growing.

A search in the fields about seriously injured plants revealed numerous small, white, footless larvæ in the earth, varying considerably in size, and for the most part much larger than those we had hatched indoors. None of the larvæ were observed in the act of feeding except one individual, a rather small one, which was engaged in devouring a seed. On being placed in glass tubes with stems of the plant they at once began to eat out the central portion, leaving only the epidermis. Similarly affected stems were quite common in the fields, but whether they were due to the work of this or another insect we find it still too much to say, although the former is the more probable, as there has been at no time anything to indicate that these larvæ attack the root, leaf, or leaf-stem portions of the plant, however near the latter might be to the surface of the ground.

Two larvæ found in the fields on the 1st of November being much larger than any previously observed, they were taken indoors and fed with stems of clover, upon the younger, tenderer portions of which they subsisted until the 2d of December, when one of them pupated, and twenty days later transformed to an adult, being at first nearly white, but assuming its normal color four days later. The second larva died before pupating.

The full-grown larva is 5^{mm} long; head small, testaceous, with brown mandibles; body white, wrinkled, first segment little larger than head, second and third larger, fourth to ninth nearly equal, gradually decreasing to thirteenth, which is very small and nearly pointed.

These larvæ when at rest in the earth lie in a hook-shaped position, the head and thoracic segments being kept at almost right angles to the fourth segment, where the rather abrupt curve begins. Prior to pupating they form a small earthen cell.

On December 9, the ground being frozen to the depth of from 2 to 2½ inches, affected plants, with the soil in which they were rooted, were dug up and brought indoors. After being thawed out this was carefully examined, and *Sitones* larvæ were found therein, varying in size from 1^{mm} in length to full grown, the major part being under 2.50^{mm} in length; but two fully grown were found, and these were in their cells preparatory to pupating. One larva, 1.50^{mm} long, began feeding as soon as thoroughly warmed. Two adults were also found, but no pupæ. One of these was kept in a breeding-cage, in a warm room, and was still alive on the 18th of the following February, when I left for an absence of a couple of months.

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* The Insects of the Clover Plant, Report N. Y. Agricultural Society, Vol. XL, for 1880. Author's edition, p. 4.

† The Rhynchophora of America north of Mexico, Proc. Am. Phil. Society, Vol. XV, No. 96, p. 115.

Besides these, two adults were observed in the fields, in the act of pairing, on the 12th of November.

On account of absence from home no examination was made until the 13th of April of the present year, when larvæ were again found in the fields, in less numbers but in about the same stage of development as during the previous December. No pupæ were observed, but two adults were found, which died soon after, without having in the mean time deposited any eggs.

On May 25 both larvæ and pupæ were found, the former in still less numbers than they were during April, but now they were, for the most part, nearly or quite full grown. An adult, taken also on this date, died on the 30th inststant without ovipositing. June 14 several adults were observed, and from this time forward they appeared in increasing numbers until August, when they seemed to reach the upward limit.

The deposition of eggs may commence in July, but we obtained none until August 7, and then only after keeping adults confined in the breeding-cage for four days; nor could we at this date observe any larvæ in plants in the fields, although very small ones were common enough in and about the tender lateral shoots early in September, but in no case were they burrowing in the main stem except in the tenderer portions, under the base of leaf-stalks, as previously indicated.

In summing up the life-history of the species, they may be said to emerge as adults as late as July, and deposit their eggs from the last of that month until cold weather begins. The larvæ, hatching within two days after the eggs are deposited, feed upon the tender portion of the clover stems, probably burrowing into them sometimes, especially when they are from one-fourth to one-half grown, and, barely possibly, subsisting in part upon the roots when older. They pass the winter, for the most part, in this stage, but occasionally as adults. The larvæ pupate in spring, and after remaining about twenty days in this state emerge as adults.

The adults seem to wander about considerably early in the season, and we have observed them traveling about on fences, upon the heads of grain, and crawling up the trunks of trees, and also found them hiding away under rubbish.

THE CLOVER-STEM MAGGOT.

(*Oscinis* sp.)

Sufficient opportunity has not been offered to study more than a portion of the probable cycle of this insect, yet the very deceptive resemblance between the work of the larvæ and those of *Sitones* renders some account of it almost a necessity in order to prevent confusion.

The adult insect is a small, rather robust, black fly. The individual larva is 4^{mm} long, with a breadth across the thoracic segments of $.6^{mm}$, footless, slightly diminishing posteriorly, with the division of the segments after the first three very obscure. Color yellowish-white, with a tinge of green, becoming nearly white at extremities; oral parts quite large and jet black. Near the posterior extremity is an abrupt ventral restriction, and on the rounded anal segment are two short, robust, brown processes, each terminating in a corolla of small circular pustules.

The puparium is 2.4^{mm} long and $.8^{mm}$ broad, elongate, oval, slightly tapering posteriorly, and rather less obtusely pointed than at anterior extremity. The two posterior processes are here reproduced, and two others, shorter and more widely separated, are placed on the anterior extremity. Color at first yellowish-white, with tinge of green, but later turning to brown, and from this to nearly jet black.

The insect was first observed by us on August 6 of the present year in the pupal stage, and within a stem of white clover, which had evidently been destroyed by it while in the larval stage. During the four succeeding days other puparia were found, but only two larvæ. From the puparia one adult emerged on August 12, others following a few days later, thereby indicating that the brood of which they were a part was rapidly approaching maturity.

The exact time and place of oviposition it was, of course, impossible to determine, but the maggots are found singly in the stem, sometimes just under the epidermis and sometimes in the center, but in either case excavating parallel channels, working from the point where the stem originated. Hence we are led to infer that the eggs are deposited near the main roots, and the larva, as its pushes forward, is provided with a continual supply of fresh-grown food, the terminal or growing portion of the stem being in part sustained by lateral roots thrown out at equal intervals. It is also possible that the eggs are sometimes placed on the young lateral stems, through which the maggots burrow their way to the main stem.

As yet we have no trace of more than the one brood mentioned, although it is not at all improbable that there may be several in a season.

REPORT ON EXPERIMENTS IN APICULTURE.

By N. W. McLain, *Apicultural Agent.*

LETTER OF TRANSMITTAL.

UNITED STATES APICULTURAL STATION,
Aurora, Ill., December 31, 1886.

DEAR SIR: I have the honor to submit herewith my report of the work done under your instructions at this experiment station during the past year.

I desire to acknowledge my obligations to yourself for the valuable suggestions and assistance given me, manifesting the deep interest you have in advancing and developing the industry of bee-keeping.

I wish also to express my thanks to those engaged in the branch of husbandry in whose interest this experiment station was established for the very kind and unanimous expressions of appreciation and encouragement, some of whom have cheerfully aided me in my work; and especially to the publishers of the following apicultural and agricultural journals for the favor shown me in publishing my report and for files of their valuable papers, namely:

The American Bee Journal, Messrs. Thomas G. Newman & Son, Chicago, Ill.; *Gleanings in Bee Culture*, Mr. A. I. Root, Medina, Ohio; *The American Apiculturist*, Mr. Henry Alley, Wenham, Mass.; *The Bee-Keeper's Magazine*, Messrs. Aspinwall & Treadwell, Barrytown-on-Hudson, N. Y.; *The Bee-Keeper's Guide*, Mr. A. G. Hill, Kendallville, Ind.; *The Canadian Bee Journal*, Messrs. Jones, Macpherson & Co., Beeton, Ontario, Canada; *Rays of Light*, North Manchester, Ind.; *The Southern Cultivator*, Atlanta, Ga.; and *The Cultivator and Country Gentleman*, Messrs. Luther Tucker & Son, Albany, N. Y.

Yours, very truly,

N. W. McLAIN,
Agent in Charge.

Dr. C. V. RILEY,
Entomologist.

THE "QUAKING DISEASE."

When bees are unable to obtain from ordinary sources a supply of saline and alkaline aliment, indispensable to their health and vigor and to the normal performance of their functions, they seek a supply from any available source. At such times they throng upon the Milkweed and Mullein, which exude a salty sap. At such times large numbers of dead bees may be found at the foot of the mullein stalks, and thousands perish in the fields, and thousands more which reach their hives, being low in vitality and unable to free themselves from the meshes of the silken fiber in which legs and wings are bound, die in the hive or crawl forth to perish. The actions of these starved and weakened bees when attempting to rise and fly or to rid themselves from the mesh of silky web causes a peculiar nervous motion, and this is one manifestation of that which is called the "quaking disease," or the "nameless disease." If examined with a microscope, many are found entangled with the filaments from the plants, and their stomachs are entirely empty.

The honey from hives containing colonies so affected has a peculiar and very disagreeable taste and odor, somewhat like that of fermented honey, indicating that some constituent essential in conserving it was lacking, and the cell-caps are dark, smooth, and greasy in appearance, and an offensive odor is emitted from the hive. An analysis of honey taken from such colonies, made by the Chemist of the Department, fails to reveal what element is lacking.

I have treated a number of apiaries so affected, using an application of strong brine, to which was added soda sufficient to make the alkaline taste faintly discernible. The hive should be opened, and each frame should be thoroughly dampened with spray from an atomizer, or the warm brine may be applied by using a sprinkler with very small holes in the rose, care being taken to use only enough to thoroughly dampen the bees and combs. The alighting-boards also should be thoroughly wet. The treatment should be applied morning and evening until the disorder disappears, which is usually in three or four days; a decided improvement being usually noticeable in twenty-four hours. The honey should be extracted and diluted by adding the brine, and, after being nearly heated to the boiling-point for ten minutes, may be safely fed to bees. The apiaries were last winter supplied with this food alone. Both wintered well. Vessels containing brine should always be kept in or near the

apiary. Pieces of burnt bone or rotten wood should be kept in the vessels of brine, and these vessels should be protected from the rain.

Another form of the so-called "quaking disease" appears to result from hereditary causes; for, if the queen be removed from the colony in which the disorder prevails, and a young, vigorous queen be substituted, in due time the disorder disappears. In very rare instances bees also gather poisonous nectar from plants, such as Fox-glove or Digitalis, the eating of which, it is reported, results in paralysis; another manifestation of the so-called "nameless disease."

THE FOUL-BROOD DISEASE.

One of the most maligant diseases incident to bees is called the "foul-brood" disease. What pleuro-pneumonia and hog-cholera are to the dairyman and swine-breeder foul-brood is to the apiarist. This disease is so stealthy and so virulent and so widely distributed, no locality in the United States being assured of immunity, that much apprehension is felt, and some of the States have enacted laws having for their object its control and extirpation. In many States the ravages of this scourge have resulted in ruinous losses to bee-keepers, and many on this account have been deterred from engaging in this profitable branch of husbandry.

During the past year I have given much attention to the study of this disease and to experiments for its prevention and cure. In making my investigations and experiments concerning the origin and nature of this disease and the means for its prevention and cure, I have collected a great amount of information from my own experience and from the experience of many others. Concerning the origin of this disease and its means of communication the evidence obtained is somewhat conflicting.

That the disease is actively contagious appears certain. That it is always communicated through the commonly accredited agencies is uncertain. That the disease is persistent and usually reproduces itself whenever the germs find the proper conditions for development is verified by experience. That the germs of this disease may be carried upon the clothing of the apiarist and in and upon the bodies of bees from one apiary to another, and that they may be borne by the wind from one hive to another in the same apiary, and that the disease germs may be liberated from the decomposing bodies of other insects and scattered over other objects with which the bees come in contact, seem probable.

That the disease is destructive to bees as well as brood, that live pollen is the medium through which the contagion is most commonly and most rapidly spread, and that the disease yields readily to treatment which is simple, cheap, and easily applied, appear to be true, in support of which I submit the following detailed account of my experiments and observations:

On the 1st day of June an apiarist having over two hundred colonies in his apiary reported to me that he had discovered two cases of malignant foul-brood, and that unmistakable evidences of its presence were apparent in twenty-five other colonies. As I knew this man was not without experience with this disease, I could not hope that he was mistaken. I knew that he had had unenviable opportunities, having been a bee-keeper for many years where this disease had been prevalent, and two years ago he himself had consigned one hundred and forty-eight colonies to the flames as incurable. I at once gave him the following formula for a remedy:

To 3 pints of soft water add 1 pint of dairy salt. Use an earthern vessel. Raise the temperature to 90° F. Stir till the salt is thoroughly dissolved. Add 1 pint of soft water boiling hot, in which has been dissolved 4 tablespoonfuls bicarbonate of soda. Stir thoroughly while adding to the mixture sufficient honey or sirup to make it quite sweet, but not enough to perceptibly thicken. To ¼ of an ounce of pure salicylic acid (the crystal) add alcohol sufficient to thoroughly cut it (about 1 ounce), and add this to the mixture while still warm, and when thoroughly stirred leave standing for 2 or 3 hours, when it becomes settled and clear.

Treatment.—Shake the bees from the combs and extract the honey as clearly as possible. Then thoroughly atomize the combs, blowing a spray of the mixture over and into the cells, using a large atomizer throwing a copious spray; then return the combs to the bees. Combs having considerable quantities of pollen should be melted into wax and the refuse burned. If there is no honey to be obtained in the fields, feed sirup or the honey which has just been extracted. If sirup is used, add 1 ounce of the remedy to each quart of the sirup fed. If the honey is used, add 2½ ounces of the remedy to each quart of honey fed. The honey and sirup should be fed warm and the remedy thoroughly stirred in, and no more should be furnished than is consumed.

Give all the colonies in the apiary one copious application of the remedy, simply setting the frames apart so that they may be freely exposed to the spray. This

treatment frequently reveals the presence of disease where it was not before possible to detect it. The quantity prescribed, applied by means of a large atomizer, is sufficient to treat one hundred and fifty colonies. Continue the treatment by thoroughly and copiously spraying the diseased colonies at intervals of three days, simply setting the frames apart so as to direct the spray entirely over the combs and bees. In order to keep the bees from bringing in fresh pollen, burn old dry bones to an ash and pulverize in a mortar and sift through a fine wire-cloth sieve, and make a mixture of rye flour and bone flour, using three parts of rye flour to one of bone flour, adding enough of the sirup or medicated honey to make a thick paste. Spread this paste over part of one side of a disinfected comb, pressing it into the cells with a stiff brush or a thin honey-knife, and hang this in the hive next to the brood. Continue this treatment until a cure is effected. Keep sweetened brine at all times accessible to the bees, and continue the use of the rye and bone flour paste while the colonies are recuperating.

As a preventive apply the remedy in the form of a spray over the tops of the frames once every week until the disease has disappeared from the apiary.

On June 20 the apiarist above referred to reported as follows:

"Number of colonies in the apiary June 1, 210. Number of colonies apparently diseased, 25. Treatment applied as directed to the whole apiary. Number of colonies actually diseased, 63. The disease present in all stages of progress; in some cases just appearing, in some well developed; in others the contents of the hives were a black mass, the brood combs nearly rotten, not an egg to be seen, and every cell of brood dead, and the stench from the hives nauseating. Have given the diseased colonies three applications, the first time extracting the honey. Effect of treatment instantaneous even upon apparently hopeless cases. Every colony save 5 is entirely free from any trace of disease, and these 5 are responding to treatment rapidly. I examined a colony to-day which two weeks ago had combs of brood almost rotten. No trace of the disease remains. I had 4,000 frames of extra comb. After hiving a few swarms, on some of them I found the disease present in every case. I then melted every one of these extra combs into wax, cleared and scalded and disinfected every hive, and hived the swarms on frames filled with comb-foundations. One of my neighbors, having an apiary of 60 colonies, had 38 cases of foul-brood, and before I was aware of it he had burned up a number of them. The remainder we treated as directed. His yard is now entirely free from disease. The cost of the remedy was just 10 cents. This prescription, if thoroughly applied according to your directions, will speedily and effectually cure the most hopeless and forlorn case of foul-brood."

It was afterwards found that the melting of the combs and scalding of the hives was not necessary.

After requesting this same apiarist to make some further tests, the nature of which will appear from what follows, August 1 he made the following report:

"In 5 of my best colonies, which had shown no symptoms of disease, I placed frames of brood from diseased colonies, treating them as I did the diseased colonies, and all evidences of disease speedily disappeared. To 1 colony from which the bees had swarmed out, leaving less than half a pint of bees between the black rotten combs and not an egg in the hive and every cell of uncapped brood dead and not more than one bee hatching to every square inch of brood, after thoroughly applying the remedy I introduced a queen just crawling from the cell. To-day I take pleasure in exhibiting this colony as one of the finest I own, lacking only a sufficient store of honey, and this without the addition to the original odorous hive and rotten combs of a single bee, cell, or brood, or anything whatever to assist, except the young queen.

"I extracted the honey from diseased colonies and treated the combs of such with the remedy as directed, and then exchanged hives and combs, giving the infested hives and combs to the healthy bees without cleansing or disinfecting a hive, and the diseased bees were given the hive and combs lately occupied by the healthy colonies. The contagion did not spread, and after two or three applications of the remedy all traces of it disappeared. I fed back the honey extracted from the diseased colonies for the bees to use in breeding, adding 2½ ounces of the remedy to each quart; and I also fed the mixture of bone-ash, rye flour, and honey as a substitute for pollen by pressing the paste into the cells on one side of a comb, and this I placed next to the brood in each hive. I would not advise any one to feed this bone-flour and rye-flour paste unless they wish to raise a great many bees. I also fed the salt, alkali, and acid mixture outside in the apiary, so that all the colonies could help themselves. No; I do not fear that any of the mixture will be stored for winter or get into the surplus apartment, as the bees seem determined to use all they can get of it in brood-rearing. All my hives are running over with bees ready for the fall honey harvest.

"As requested, I placed frames of sealed honey from diseased colonies in healthy

colonies, and the disease was not communicated; but the frames from which the honey had been extracted, such as contained pollen, uniformly carried with them the contagion, unless the combs were first thoroughly sprayed with the antidote, and colonies gathering no pollen, or but little pollen, recovered much sooner than those gathering pollen in considerable quantities—that is to say, the more pollen, the more treatment required.

"In reply to your question asking by what means and in what manner the disease was communicated to my apiary, I answer: I at first thought that it had originated spontaneously, but later and more careful inquiry leads me to believe that I introduced it into my apiary through my own carelessness. Both I and my neighbor (to whom reference was made in a former report) spent a day in some apiaries some distance from home in which the disease was raging. It would seem true that we brought the contagion home in our clothing. Other apiarists in our county who kept away from the contagion had no trouble. As to the progress of the disease in individual colonies, I would say that three or four weeks from the time the first cells of diseased brood are noticeable is sufficient to complete the ruin beyond redemption. I am surprised to hear that in some localities a colony may be affected for three or four months before ruin is complete. I have succeeded in raising some queens from one of these diseased colonies, treated with the remedy without removing the comb-frames, and I will give them every possible chance to reproduce and propagate the disease. I have no fears of a return of the disease where the treatment has been thorough."

2. Number of colonies in the apiary, 14. Every colony nearly ruined by the disease in most malignant form. This apiary is located on the same ground where 145 colonies perished last year from the same cause. The whole yard had been swept clean, everything had been burned up, and entirely new stock procured. Twelve colonies in this apiary were treated by copious and thorough applications of the remedy simply by setting the frames apart in the hive so that the spray could be directed over both sides. The frames containing brood were not removed from the hive, neither was the honey extracted. The treatment was applied every three or four days, and in three weeks the colonies were free from all appearance of disease. The other 2 colonies were treated with what is known as "the coffee cure," finely ground coffee being used as an antiseptic. The coffee failed to furnish any relief. Being dusted over and into the cells, it killed the little remaining unsealed brood. The salt, alkali, and acid remedy being applied, these 2 colonies also rallied, and "everything is all right now," was the last report.

3. Number of colonies, 100. Number apparently diseased, 48. A number of colonies had already been burned when the disease was reported. The remedy was thoroughly applied as directed, and in fifteen days the contagion had disappeared.

All the evidence so far obtained seems to prove that pollen is the medium through which the contagion is commonly introduced into the hive and by which it is communicated to both bees and brood.

The bacteria, "the disease germs," having been lately deposited on the pollen (from what source is not positively known, but probably from the decomposing bodies of other insects) before the organisms are washed from the blossoms by the rain or killed by the heat of the sun, as they lie exposed to his rays without any element essential to their culture and growth, are carried and stored with the pollen in the cell, or pass into the digestive system along with the live pollen taken by the bees for their own nourishment. By this means these agents of destruction are introduced into the organism of the bees, and through the same medium are they introduced into the cells of the uncapped larvæ. The bacteria, having found a lodgment in the organism of the bee, may or may not cause speedy death. If the bees are young and vigorous they may resist the ravages of the infection, yielding only after the organism is riddled with the bacteria, but if the bees are old and low in vitality the infection, if left to itself, brings speedy ruin. In the spring of the year I have dissected bees which had passed the winter in a colony in which this disease was present when the bees were put away in winter quarters the fall before. Their bodies had been completely honey-combed by the bacteria.

The fact that if a diseased colony is removed from the infested combs and hive and placed in an empty hive or in a hive with frames supplied with comb-foundation, even if the new hive be at once placed on the old location and the old hive and infested combs be burned and the bees at once liberated, the disease commonly disappears, seems also to furnish additional proof that the contagion is usually carried into the hive in the pollen, and, further, that the "disease germs" do not long retain their virility if exposed to the rain and rays of the sun; otherwise the bees would continue to carry in the infection. The bees being compelled to consume the contents of their honey-sacks in building new combs, none of the germs remain to be regurgitated in the new cells; but by this practice the bees are left to the tender

mercies of the bacteria, unless they be treated with an antidote. For obvious reasons the queens in such colonies should in any event be superseded as soon as possible. This method of treatment also contemplates the destruction or renovation of all hives and frames, the destruction of all broods, and the melting of all combs; a large percentage of the capital in honey-producing.

Another reason for believing that, except in rare cases, the disease is introduced by means of pollen is found in the fact that the larvæ rarely ever exhibit any symptoms of disease until about the time when the process of weaning begins, at which time the character of the food is changed from the glandular secretion, the pap, to the partially digested and undigested food. Live pollen is then added to the larval food, and with it the bacteria in greater or less numbers; growth is arrested; death ensues; putrification follows, and the soft pulp, of a grayish-brown color, settles to the lower side of the cell. As the mass dries up it becomes glutinous and stringy and reddish-brown in color and emits an offensive odor. Some of the larvæ will be partially capped, some completely capped, and some left uncapped, the condition in which the brood is left depending, I believe, upon the virulence with which the disease attacks both bees and brood. The remedies prescribed appear to destroy the bacteria and cure the bees of the contagion and restore them to natural vigor. The worker bees then cleanse the hive of dead bees and brood and clean out and renovate the cells, and the colony resumes its normal condition.

That the contagion may sometimes be borne from hive to hive by the wind appears to be true, as it was observed in one of the apiaries which I treated for this disease during the past summer that of a large number of diseased colonies in the apiary, with the exception of two colonies, all were located to the northeast of the colony in which the disease first appeared. The prevailing wind had been from the southwest.

That the disease germs may be carried upon the clothing and hands appears probable, from the fact that in one neighborhood the disease appeared in only two apiaries, the owners of which had spent some time working among diseased colonies at some distance from home, while other apiarists in that locality who had kept away from the contagion had no trouble from foul-brood.

THE CONTROL OF REPRODUCTION.

The improvement which has been made in mechanical devices and methods of management by the scientific and practical apiarists of the United States during the past twenty-five years has resulted in establishing the claims of the industry of bee-keeping to a place among the various branches of rural husbandry which are the acknowledged sources of the nation's wealth. Improvements in the art of bee-keeping and in the devices by which the art is practiced are continually being made, and the degree of advancement made in the past is an earnest of the progress awaiting development in the future.

Improvements in devices and methods of management and importing races of bees reported to possess desirable qualities and characteristics have chiefly absorbed the attention of American bee-keepers. It is not strange that reliance has been placed upon these resources as the means by which the best results were to be realized, rather than upon a persistent and skillful application of the laws of heredity and descent and dependence upon the influence of intelligent selection and skillful crossing as a means for developing the highest attainable standard of excellence in *the bee*, the chief factor in permanent advancement.

The difficulties attending the control of the process of reproduction, of applying the laws of heredity and descent, and securing the influence of persistent, intelligent selection in breeding bees have appeared to be almost insurmountable. The very persistent efforts which have been made to improve the bees of the United States by yearly importations of the best races in their purity has also been attended with serious drawbacks and hindrances. These bees, bred for countless generations in a foreign habitat and under climatic conditions widely different from ours, are here submitted to conditions of domestication for which they are ill adapted. Any modification and adaptation of habits, instinct, and physiological structure which may have been secured by breeding a few succeeding generations under the altered conditions and requirements incident to domestication in the United States have been lost with each fresh importation of ancestral stock, and the work of securing the variability and adaptability of instinct, habit, physiological structure, and functional capacity essential to domestication here must be begun *ab initio*.

That some practical method might be discovered by which the process of reproduction could be controlled has long been the hope of all progressive apiculturists. With the control of fecundation assured, progress in scientific apiculture would be rapid and permanent.

In obedience to your instructions I have continued my experiments in striving to discover a practical method by which the fecundation of queen bees may be controlled. This I have endeavored to accomplish by two different methods, in both of which I have been in a degree successful. During the past summer, however, a drought set in in May, almost with the beginning of the breeding season, which was said to be the severest and most protracted known in this locality for twenty-five years. No rain fell during eleven weeks, and during the four weeks next succeeding the eleven weeks without rain we had but three light showers, scarcely sufficient to lay the dust, practically resulting in an unbroken, all-consuming drought fifteen weeks in duration. Under such conditions I found it impossible to bring many of my experimental tests to a successful issue.

Having discovered last year that it was possible to introduce the drone sperm into the spermatheca of the queen bee during the term of orgasm by artificial means, and that fecundation was practicable by such means, I attempted to perfect a method by which this could be done with ease and certainty. For the purpose of holding the queen bee in position for introducing the drone sperm I made what I call a queen-clamp, which consists of a block of wood 2 inches square and 4 inches long, in one end of which is an opening in size and shape like the upper two-thirds of a queen-cell, with the small end up. This block is sawed in two in the middle, leaving half the cell-shaped opening on either half. Grasping the queen by the wings or thorax I place her in one half of the cell-shaped opening and carefully close the other half over her. I then place a rubber band around the block and stand it on end. This leaves the queen in position, head downward, the lower half of her abdomen protruding, and confined in such a manner that she cannot receive any injury. For the purpose of appropriating and depositing the male sperm I used a hypodermic syringe. I removed the sharp injecting needle, and in its place substituted a nozzle having an opening of sufficient size to admit a knitting-needle of medium size. Over this nozzle I slipped a small, smooth tube, drawn to a point so small that the opening in the small end is not more than half as large as that in the nozzle. After selecting the drone I wish to use, I grasp the head and thorax between the thumb and finger, and by a continued pressure cause him to perform the expulsion act. I then remove the bean in which the spermatozoa are massed and squeeze the contents into a very small glass receiver, an eighth of an inch in depth and in diameter. I then add a drop of glycerine diluted with warm rain water, and take up the spermatozoa with the syringe, using the wide nozzle. I then slip the cap having a fine smooth point over the nozzle and inject the spermatozoa into the vulva of the queen. The queen, which has been held in position by the clamp while the preparations were being made, naturally bends the abdomen downward whenever so confined. The vulva is easily opened to admit the point of the fine nozzle-cap when the abdomen is lifted up straight. Of twenty-seven queens treated by this method the last week in May and the first week in June six proved to be successfully fertilized. After that time, although I was persistent in my efforts to succeed and made many and repeated trials, I met with success only occasionally.

Another method by which I succeeded in fertilizing a few queens in May, before the bees began killing the drones, was in the manner described in my report of last year. I took a number of young queens from nursery cages, clipped their wings, and introduced them to queenless nuclei. When they were seven days old, orgasm being well progressed, I placed them each in turn in a queen-clamp, and, holding them back downwards, I picked drones from a comb taken from a populous hive, and caused them to expel the generative organs, and selecting those in which the contents appeared of the color and consistency of albumen, I placed drops of the seminal fluid upon and in the vulva of the queen, which were eagerly received. After the introduction of the drone sperm these queens were treated by the bees as fertile queens, and in one or two days assumed the appearance of fertile laying queens, and in from three to six days began to lay fecundated eggs.

The fact that I did occasionally succeed in fecundating queen bees by these methods, which proved upon trial as prolific as any queens I had which had been naturally fertilized, queens which I had hatched in an incubator and in nursery cages, whose wings I had mercilessly clipped as soon as they had crawled from the cell, and which I knew had never been upon the wing, seemed to furnish reason to hope that I would be able to discover a method which would be uniformly successful. The hope of reaching this much-desired result made me persist in the face of discouragements incident to experimental work in breeding bees during the prevalence of a protracted drought. I am by no means discouraged by the partial success now realized. On the contrary, I am hopeful that under more favorable conditions better results may be obtained, and until other and untried resources fail I should not feel warranted in abandoning effort.

Observation and experiment lead me to believe that drone bees differ in degrees

of procreativeness, and that the development and exercise of the procreative faculty are under the control of the worker bees.

First, there appeared to be drones of the impotent sort. If such be taken between the thumb and finger, no pressure short of crushing is sufficient to expel the sex organ. When forced to position external to the body, or if removed by a dissection, the organs are found to be nearly or quite empty, the few spermatozoa being massed in a hard lump, and but little mucus being present, and that little watery and clear and having no consistency.

Another sort of drones are those in which the mucus surrounding the spermatozoa is thick and curdy. With this sort I have not been able to fertilize a queen. The procreative principle is present in quantity, but the element in which it may be liberated and floated into the organs of the queen appears to be wanting.

A third sort of drones are those in which the sex organs are completely filled with spermatozoa and an abundant supply of albuminous fluid. It is only with this latter sort that I have been able to succeed in fecundating queens.

The facts observed seem to warrant the belief that it is the prerogative of the worker bees to determine the degree of development and dominate the function of the drones as they do the succeeding generations of workers and queens, the superior intelligence of the workers ordering the entire economy of the hive. During the first half of the severe and protracted drought of the past season I was able to rear a few drones by resorting to the usual methods employed for stimulating drone-rearing, but one-third of the entire number proved upon trial to be of the sort which I believe to be impotent, and nearly all of the remaining two-thirds were of the second class, not more than 5 or 10 per cent. of the entire number being furnished with the albuminous liquid necessary to enable the drone to voluntarily perform the expulsion act and complete the function of copulation, the filling of the spermatheca of the queen; for I am led to believe that the presence of this fluid, more than any odor or other influence from the presence of the queen during orgasm, excites in the naturally frigid drones the sexual desire and assists in the execution of the expulsion act and furnishes the element in which the spermatozoa are floated into the spermatheca, and also that the workers intelligently and purposely determine the sexual development and dominate the fitness, the desire, and capacity of the drone, as they do the physical development, the fitness, the desire, and capacity of worker and queen bees for the natural performance of their individual functions; that is to say, if drones are reared during a drought by artificially approximating the conditions under which the desire for drone-rearing normally arises, only a small percentage of the number will be sufficiently furnished with the food essential to complete sexual development, the counterpart of which is seen in a less degree in the rearing of worker larvæ; and, further, if there is a failure of honey or if for any reason the swarming impulse is absent and no emergency exists for the forming of a new colony, very few of the sexually mature drones are supplied with the food-elements essential in producing the secretion which excites sexual desire and supplies the agency by which the spermatozoa are freed and floated into the spermatheca, the counterpart of which is seen in the refusal of the worker bees to copiously supply the queen with the rich glandular secretion essential to oviproduction whenever their instinct warns them that ovipositing should cease and that further brood-rearing would only be a waste of energy, resulting in a generation of consumers and non-producers; for the queen is only a mother, and in no sense a majesty; only a machine, not a monarch. Other facts in my experience might be mentioned in support of this belief.

October 15, Mr. Otis N. Baldwin, of Clarksville, Mo., wrote me that he had met with success in practicing the method of fertilization described in my report of last year and that he had discovered that drones were of three kinds, namely: "Dwarfed, immature, and ripe." As directed by your letter of instructions of November 5, I went to Clarksville and interrogated Mr. Baldwin concerning his experience and observations, and I herewith give the substance of his statement made in reply to my questions. He said, "I first go to my nursery and take the queens and cage them. I then go to my hive of drones and pick out as many as I think I may need, and then proceed in the manner you describe in your report of 1885. I believe the whole secret of success lies in the drones, and I am not able to tell how old the drone must be, or how the right condition is brought about, or whether it was originally intended that only a very small percentage of drones should be capable of fertilizing a queen. I have, however, discovered that there are three kinds of drones. First, the drone which when squeezed bursts with apparently dry organs of generation. Second, drones which burst with an abundance of seminal fluid resembling a mixture made by adding bromides to a silver solution. Third, drones which bursting show a fluid resembling albumen. With the two former kinds I have succeeded in fertilizing a single queen. With the latter I have fertilized over two hundred queens the past

season with but few failures after I found out the difference in drones. I carefully grasp the thorax of the queen between the thumb and finger of the left hand and with the right I pick up the drone which I have selected and press the thorax and abdomen of the drone until the generative organs are expelled, using as many as I need until I find one in which the color and consistency of the fluid suits me. Sometimes only a few of the right kind can be found in as many as one hundred. I place a few drops of the male fluid upon the vulva of the queen, which is eagerly received, using one, and only one, drone for each queen. I have fertilized queens by this method that were not a day old, and others more than fifteen days old, and after clipping their wings introduced them to their colonies, and they began laying in from six to eight days and were satisfactorily prolific. As nearly as I could tell, those fertilized early were more prolific than those treated after they were ten days old, but the right condition of the drone is very essential. It is very difficult to get drones ripe enough before the first half of May and after the first half of August, but during June and July this method may be operated with gratifying results. Queens fertilized by this method and directly introduced into a queenless colony are rarely ever molested by the bees. I clipped the wings of the first twenty or twenty-five queens I succeeded in fertilizing by this method, and finding the method worked to my satisfaction and with but few failures, I clipped no more wings."

The experience here detailed, as far as it relates to the procreativeness of drones, is in agreement with the facts within my own observation already set forth. The claim that a very large number of queens were successfully fertilized as set forth, and that, too, with but few failures in the whole number attempted, is lacking in the element of absolute certainty and completeness of detail which would entitle it to acceptance as of any scientific value. Mr. Baldwin assured me that "there could have been no mistake about it;" but in order to effectually guard against all possibility of the test being abortive, all the queens claimed to have been artificially fecundated should have had their wings thoroughly clipped before they were liberated. But the fact that the repeated successes were realized when the young queens were clipped upon being taken from the nursery cage, never having had opportunity to bear their weight upon their wings, is an encouraging step in advance towards the solution of the most difficult problem in practical bee-keeping. Another season, with the presence of favorable conditions, will determine the practicability and value of this method.

FERTILIZATION IN CONFINEMENT.

Realizing that natural methods nearly always possess advantages over artificial methods, I determined if possible to gain control of reproduction by the fertilization of queens in confinement. That some inexpensive and practicable method might be devised by which the natural mating of queens in confinement could be secured has very long been hoped for by all progressive apiarists. Very many attempts, in a variety of ways, some of which involved the outlay of considerable sums of money, have been made, but difficulties apparently insurmountable have been encountered.

I removed the queens from 6 colonies which I had had confined in the house for experimenting with bees and fruit, a house 10 feet by 16 feet, 8 feet high, partly covered on the sides with wire-cloth, a wire-covered sash in the gable, and large screen wire-covered doors in each end. These were strong colonies, which had been confined in this house for thirty days and had learned the location of their hives, and from these the bees flew daily in great numbers, returning frequently to their hives. Into these 6 colonies I introduced virgin queens hatched from cells which I had placed in wire cages. Into each colony the virgin queen was placed without being removed from the cage in which she was hatched. In due time they were accepted and liberated. The day these queens were five days old I liberated about ten drones near to the entrance of each of these hives. These drones were brought from hives in the apiary, and upon being liberated most of them persisted in flying against the wire-covered sides and windows in the gable, and few ever entered the hives. Here again there was frigidity or disability apparent among the drones. When the young queens flew from the hive seeking a mate they mingled among the drones, crawling over them and caressing them with their antennæ, meeting with no response. These queens, with one exception, seemed to have no difficulty in getting the location of their respective hives. The result of this trial was, one queen of the six was fertilized, and after she had laid eggs with regularity in two-thirds of the cells on both sides of one frame, after clipping the queen's wings, I removed this frame, with the queen and adhering bees, to a nucleus in the yard, and from the eggs laid in confinement worker bees hatched in due time, and the queen continued to lay as long as the nucleus was fed, there being nothing in the fields for the bees to gather. All the eggs laid by this queen were

fecundated eggs. Being convinced that as far as the queens were concerned the difficulties in the way of success were not insurmountable, and that the main trouble was that the drones had not been furnished by the workers with the glandular secretion or the food suitable for producing the albumenlike secretion which I had been led to believe essential to produce sexual desire and to assist in the performance of the copulative act, from these same colonies I removed the remaining unmated queens, and to each I introduced another virgin queen as before.

I then went to a distant apiary, and secured an unusually strong colony which was under the swarming impulse. A few queen cells were being built and a moderate supply of drones was present. This was late in the season. This colony had not cast a swarm during the year, and was the only one I could find, after considerable search and inquiry far and near, having any drones, and probably owing to the excessive drought only an occasional one of the number examined had been prepared by the workers for the procreative function. I took this colony home and placed it in the wire-covered house at the end opposite that in which the virgin queens were located. I clipped the wings of the old queen so that she could not leave the hive, and upon being liberated the workers and drones of this hive made less effort to escape than those brought in from the apiary near by, and some seemed reconciled to their new surroundings. The workers soon learned their location and drones were soon to be found in nearly every hive in the house. The result of this trial was that three of the six queens were fertilized, and as soon as they had each laid five or six hundred eggs I clipped their wings and removed them, together with their colonies, to the yard and fed them, and all the eggs laid by these queens produced worker bees. I am much encouraged by the success so far realized under conditions so unfavorable.

With the return of spring I hope to follow out your suggestions and continue the test, using a large wire-covered inclosure for the purpose; with hives so arranged on the sides that the worker bees may have unobstructed flight, while the drones and queens, being restrained by means of queen-excluding zinc placed before the outside entrance to the hive, may fly and mate within the inclosure and readily return to the hives from whence they came. If practical control of reproduction can be secured by so simple and inexpensive a method—and the facts from my experience as given above seem to warrant the conclusion that this is true—then the Rubicon of scientific apiculture is passed.

EXPLANATION TO PLATES TO REPORT OF ENTOMOLOGIST.

Where figures are enlarged the natural sizes are indicated in hair-lines at side, unless already indicated in some other way on the plate.

EXPLANATION TO PLATE I.

THE COTTONY CUSHION-SCALE.

(Original.)

FIG. 1.—*a*, adult male—enlarged; *b*, hind tarsus of same; *c*, wing and poiser of same, showing hooks and pocket—still more enlarged.
FIG. 2.—*a*, newly hatched larva from below—enlarged; *b*, antenna of same; *c*, tarsus—still more enlarged.
FIG. 3.—Adult female, side view, showing the pale, greenish-gray form and with part of egg-covering torn away, showing the carmine eggs and egg-stain—enlarged.
FIG. 4.—Adult female, dorsal view, showing reddish-brown form—enlarged.
FIG. 5.—Male cocoon—enlarged.
FIG. 6.—Branch of orange tree with mass of insects *in situ* and as they appear soon after death—natural size.

EXPLANATION TO PLATE II.

THE COTTONY CUSHION-SCALE.

(Original.)

FIG. 1.—Outline of the egg—greatly enlarged.
FIG. 2.—Dorsal view of newly-hatched larva—greatly enlarged.
FIG. 3.—*a*, female larva, second stage, ventral view—greatly enlarged; *b*, antenna of same—still more enlarged.
FIG. 4.—Female larva, third stage, ventral view—greatly enlarged.
FIG. 5.—Adult female (fourth stage), dorsal view—greatly enlarged; *a*, antenna—still more enlarged.
FIG. 6.—Greatly magnified portion of lateral border of adult, showing bases of glassy filaments.
FIG. 7.—Male larva, second stage, ventral view—greatly enlarged.
FIG. 8.—Male pupa, ventral view—greatly enlarged.

EXPLANATION TO PLATE III.

ENEMIES OF THE COTTONY CUSHION-SCALE.

(Original.)

FIG. 1.—*Isodromus iceryæ*—greatly enlarged.
FIG. 2.—*Blapstinus brevicollis*—enlarged.
FIG. 3.—*Blastobasis iceryæella*—enlarged.
FIG. 4.—*Largus succinctus*—enlarged.
FIG. 5.—*Corizus hyalinus*—enlarged.
FIG. 6.—*Forficula* found preying on *Icerya*—enlarged.

EXPLANATION TO PLATE IV.

(Photo-engraved from a photograph.)

A lemon orchard at Los Angeles, infested by Cottony Cushion-scale.

EXPLANATION TO PLATE V.

(Photo-engraved from a photograph.)

Spraying outfit used in California in operation against the Cottony Cushion-scale.

EXPLANATION TO PLATE VI.

THE SOUTHERN BUFFALO-GNAT.

(Original.)

FIG. 1.—*Simulium pecuarum:* Larva—enlarged.
FIG. 2.—*a*, ventral view of head of larva; *b*, lateral; *c*. dorsal view of same—all greatly enlarged.
FIG. 3.—*a*, mentum of larva; *b*, labium, *c*, labrum of same—all greatly enlarged.
FIG. 4.—Pro-leg of larva—greatly enlarged.
FIG. 5.—*a*, antenna of larva; *b*, mandible of same—greatly enlarged; *c*, tip of mandible—still more enlarged.
FIG. 6.—Maxilla of larva—greatly enlarged.
FIG. 7.—Tip of abdomen of same, showing breathing organs—greatly enlarged.
FIG. 8.—Pupa—enlarged; *a*, *b*, *c*, spines of dorsal and ventral surface of abdomen of same—still more enlarged.

EXPLANATION TO PLATE VII.

THE SOUTHERN BUFFALO-GNAT AND THE TURKEY-GNAT.

(Original.)

FIG. 1.—*Simulium pecuarum:* Fan of larva—greatly enlarged.
FIG. 2.—*Simulium meridionale:* Larva—enlarged.
FIG. 3.—Same: *a*, antenna; *b*, mandible—greatly enlarged; *c*, tip of mandible—still more enlarged.
FIG. 4.—Same: Mentum—greatly enlarged.
FIG. 5.—Same: Breathing organs — greatly enlarged.
FIG. 6.—Same: *a*, empty pupa-case; *b*, case with pupa projecting from it—enlarged.

EXPLANATION TO PLATE VIII.

BUFFALO-GNATS.

FIG. 1.—*Simulium pecuarum:* Head of adult male—greatly enlarged. (Original.)
FIG. 2.—Same: Head of adult female—greatly enlarged. (Original.)
FIG. 3.—Same: Adult female from side—enlarged. (Original.)
FIG. 4.—*Simulium meridionale:* Adult male from side—enlarged. (Original.)
FIG. 5.—*S. pecuarum:* Dorsal view of adult female—enlarged. (Original.)
FIG. 6.—*S. meridionale:* Dorsal view of adult female—enlarged. (Original.)
FIG. 7.—*Simulium* sp.: *a*, portion of egg-mass from side; *b*, same, from top; *c*, *d*, individual eggs—enlarged. (After Barnard.)

EXPLANATION TO PLATE IX.

FIG. 1.—Larva of *Chironomus* sp.: *a*, dorsal view with pediform appendages retracted and jaws closed; *b*, lateral view with same parts extended; *c*, egg-mass—all enlarged; *d*, maxillary palpus; *e*, labial palpus; *f*, labium; *g*, mandible—still more enlarged. (After Riley.)
FIG. 2.—*Chironomus plumosus:* *a*, adult, dorsal view; *b*, pupa, ventral view—enlarged. (Original.)
FIG. 3.—*Hydropsyche* sp.: *a*, dorsal view of larva—enlarged; *b*, side view of anal hook of same—still more enlarged. (Original.)
FIG. 4.—Same: Side view of head and first thoracic segment of larva — enlarged. (Original.)
FIG. 5.—Same: Web of larva—enlarged. (Redrawn from Clarke.)

EXPLANATION TO PLATE X.

THE FALL WEB-WORM.

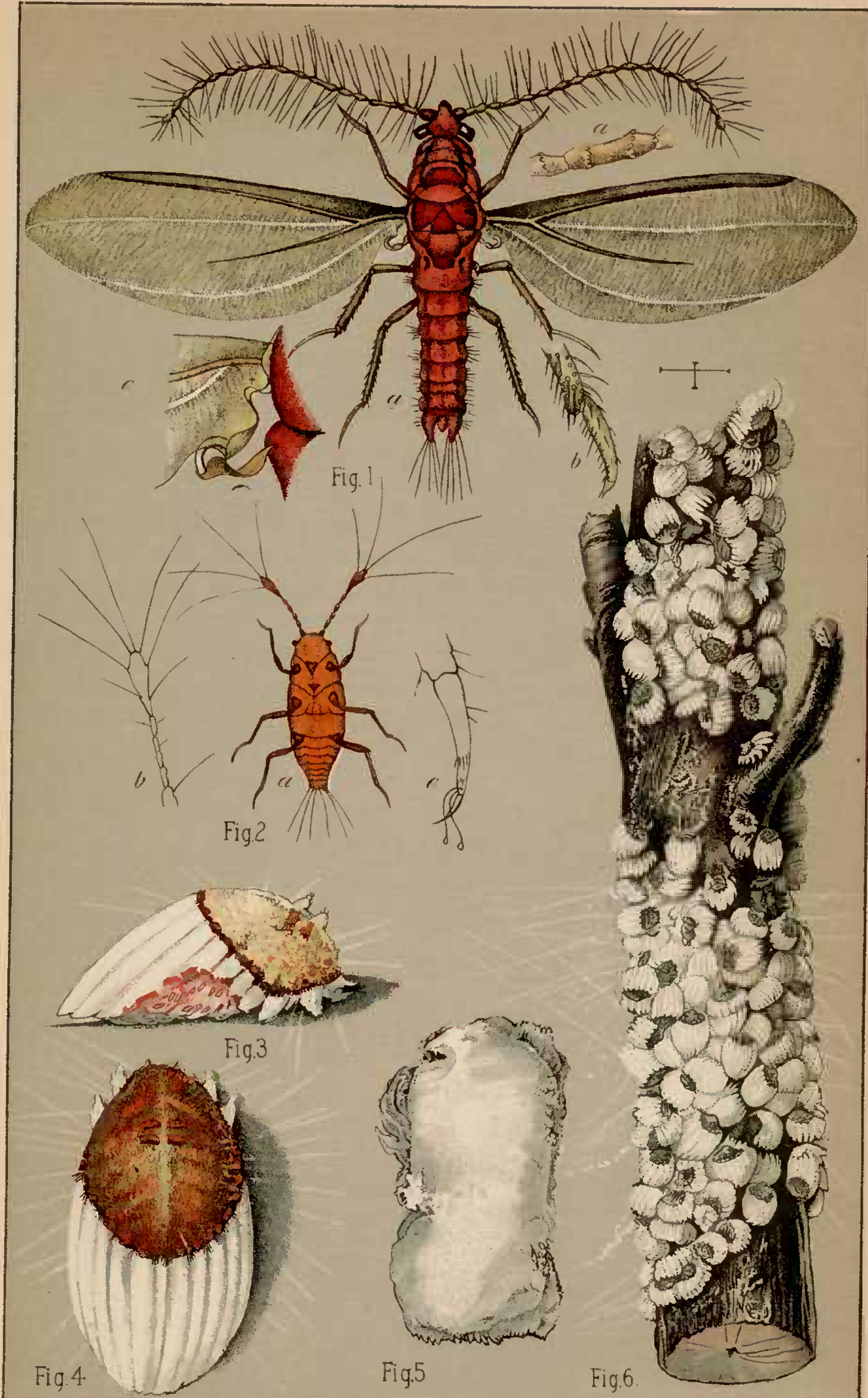
(Original.)

FIG. 1.—*a*, dark larva from side; *b*, light larva from above; *c*, dark larva from above; *d*, pupa, ventral view; *e*, pupa from side; *f*, adult—all slightly enlarged.
FIG. 2.—*a-j*, wings of a series of adults, showing graduation from pure white form (*cunea*) to one profusely spotted with black and brown (*punctatissima*)—natural size.
FIG. 3.—*a*, moth ovipositing upon leaf—natural size; *b*, a few eggs *in situ*—enlarged.
FIG. 4.—*Meteorus hyphantriæ:* *a*, adult; *b*, cocoon—enlarged.

EXPLANATION TO PLATE XI.

(Photo-engraved from a photograph.)

View of a Washington street in late September, 1886, showing complete defoliation of the Poplars on the west side and almost complete exemption of the Maples on the east side.



C.V. RILEY. L. SULLIVAN, PINX.

GILES LITHO & LIBERTY PRINTING CO. N.Y.

THE ORANGE ICERYA, OR COTTONY-CUSHION SCALE.

(Icerya purchasi–Maskell.)

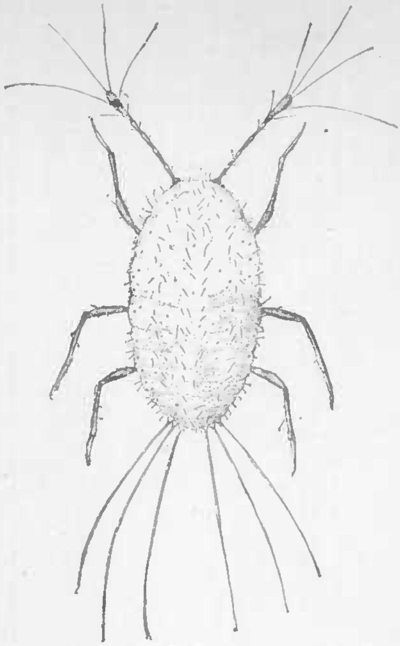


Fig. 2.

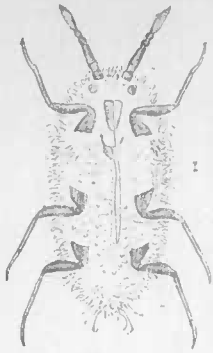


Fig. 7.

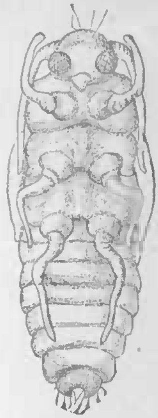


Fig. 8.

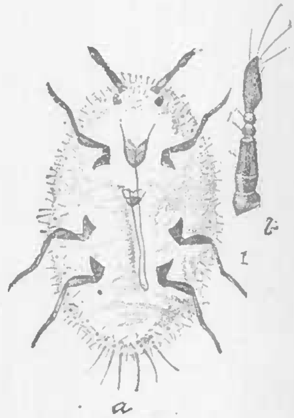


Fig. 3.

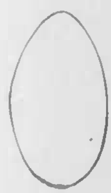


Fig. 1.

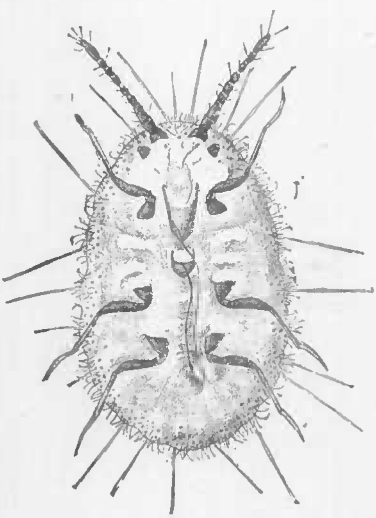


Fig. 4.

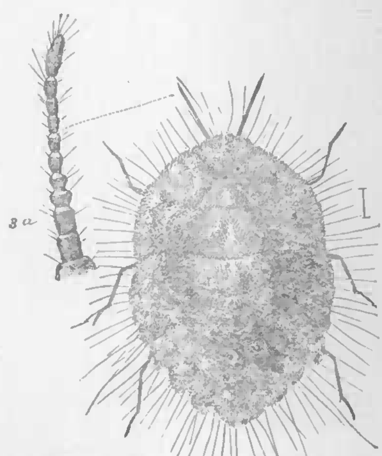


Fig. 5.

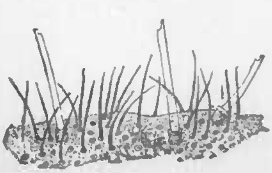


Fig. 6.

THE COTTONY CUSHION-SCALE.

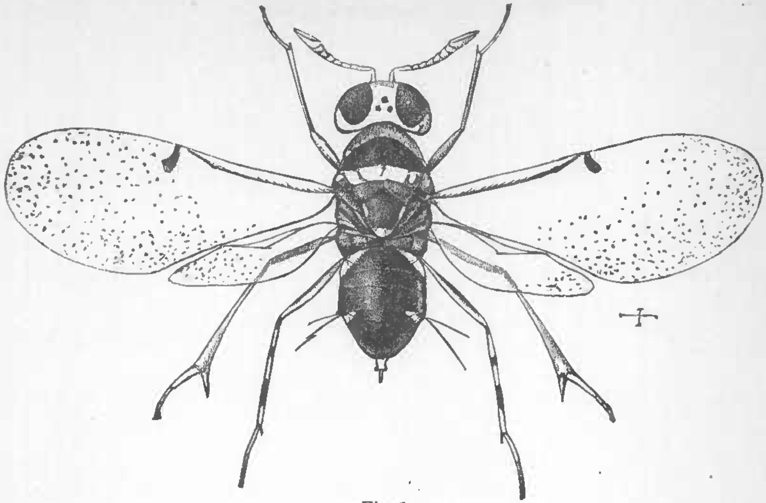


Fig. 1.

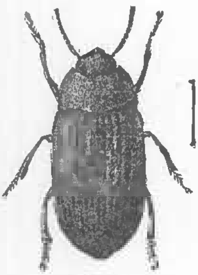


Fig. 2.

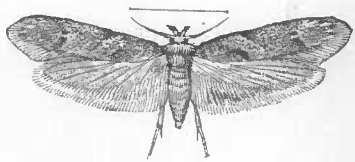


Fig. 3.

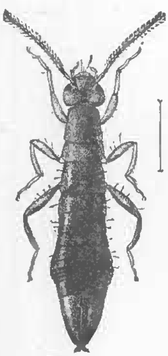


Fig. 6.

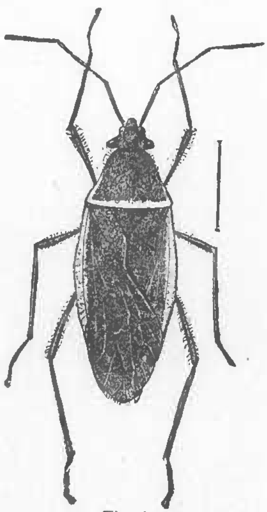


Fig. 4.

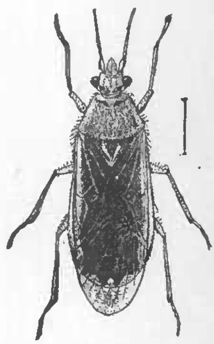
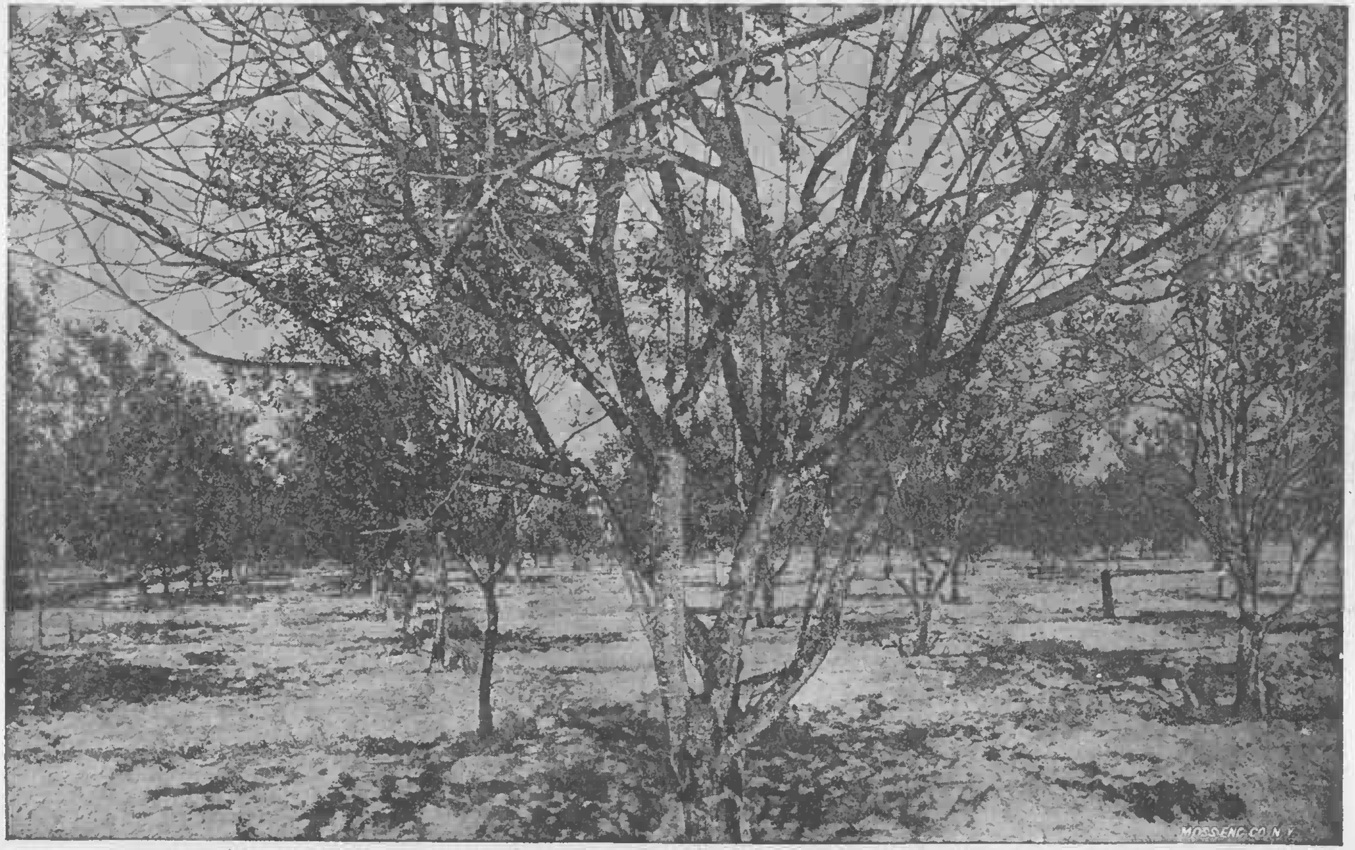
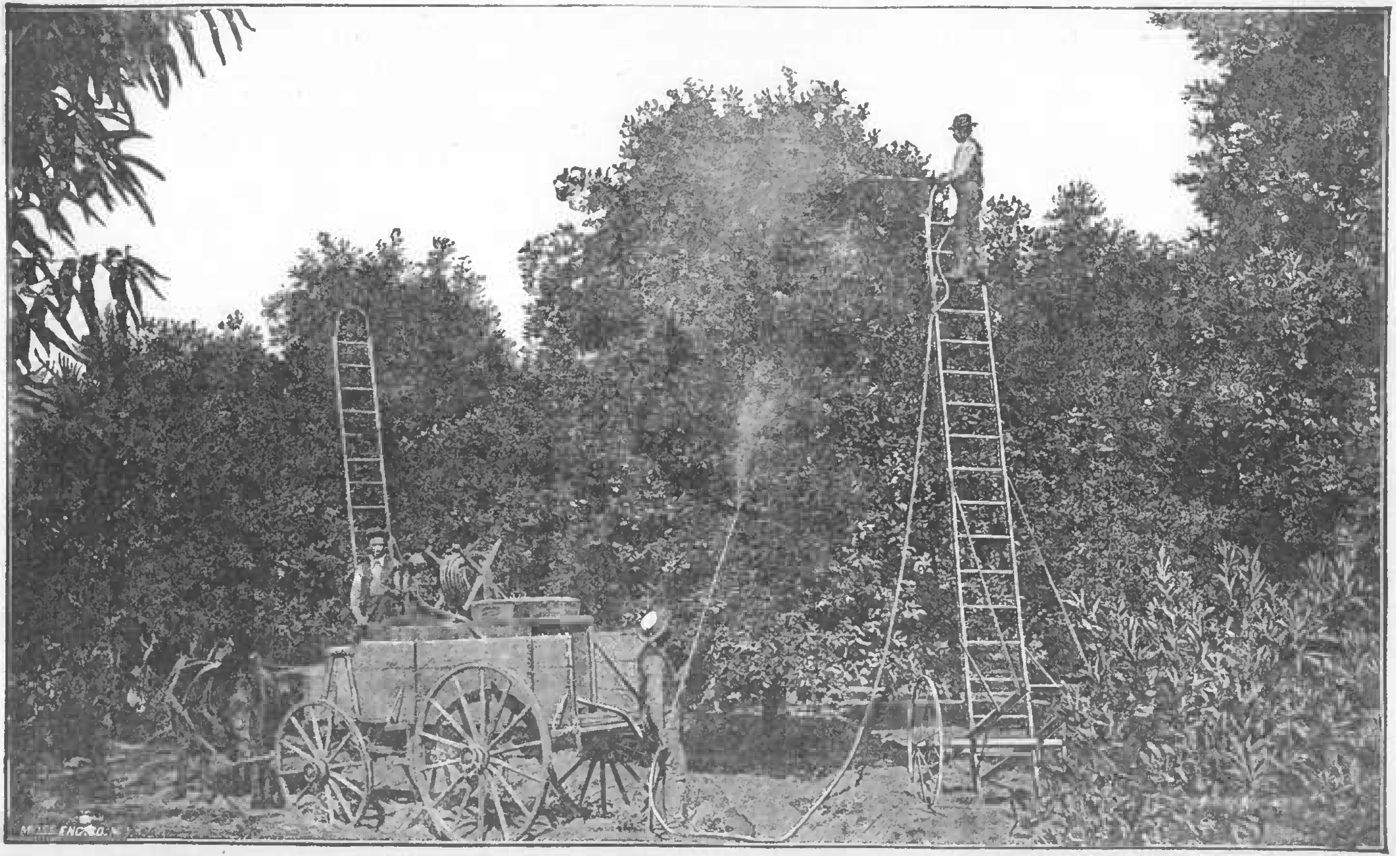


Fig. 5.

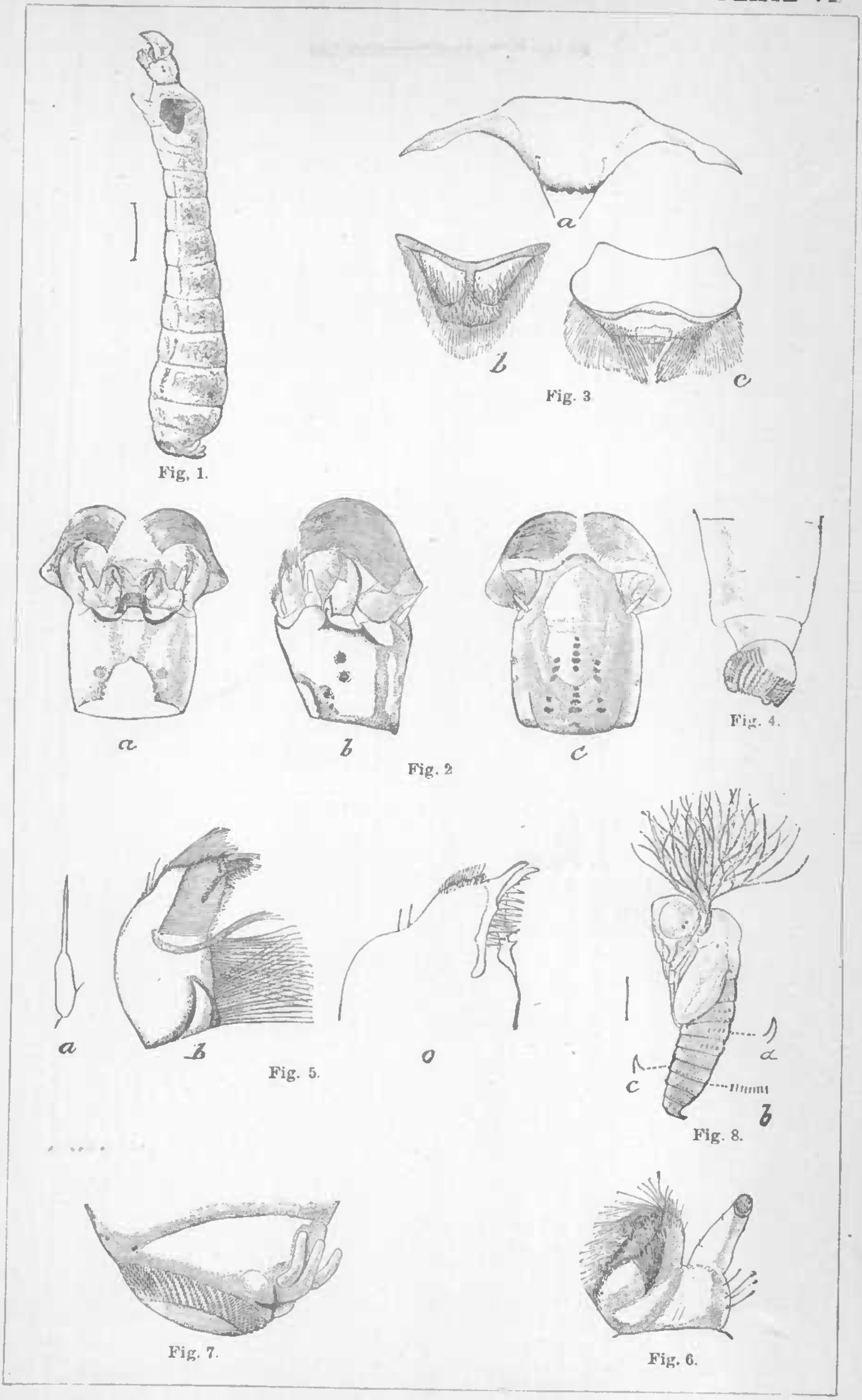
ENEMIES OF THE COTTONY CUSHION-SCALE.



LEMON ORCHARD INFESTED BY COTTONY CUSHION-SCALE.



SPRAYING OUTFIT IN OPERATION AGAINST COTTONY CUSHION-SCALE.



THE SOUTHERN BUFFALO GNAT.

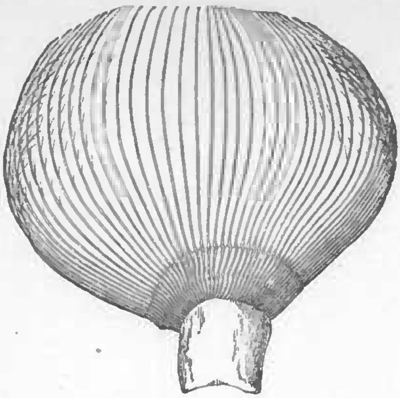


Fig. 1.

Fig. 2.

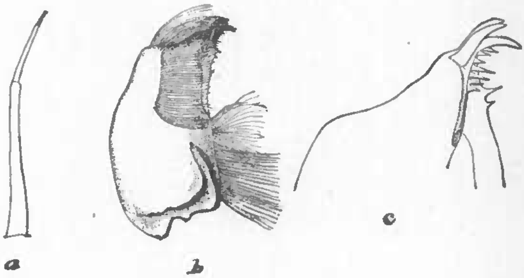
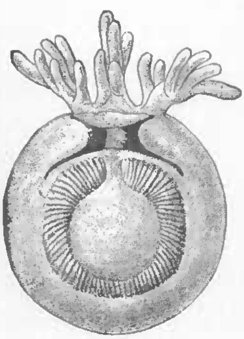


Fig. 3



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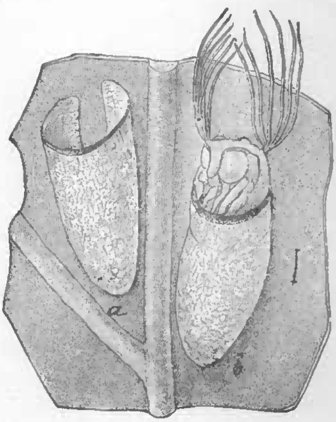

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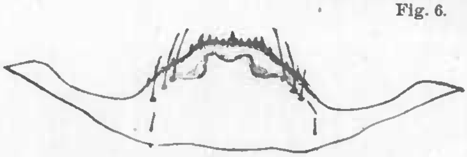
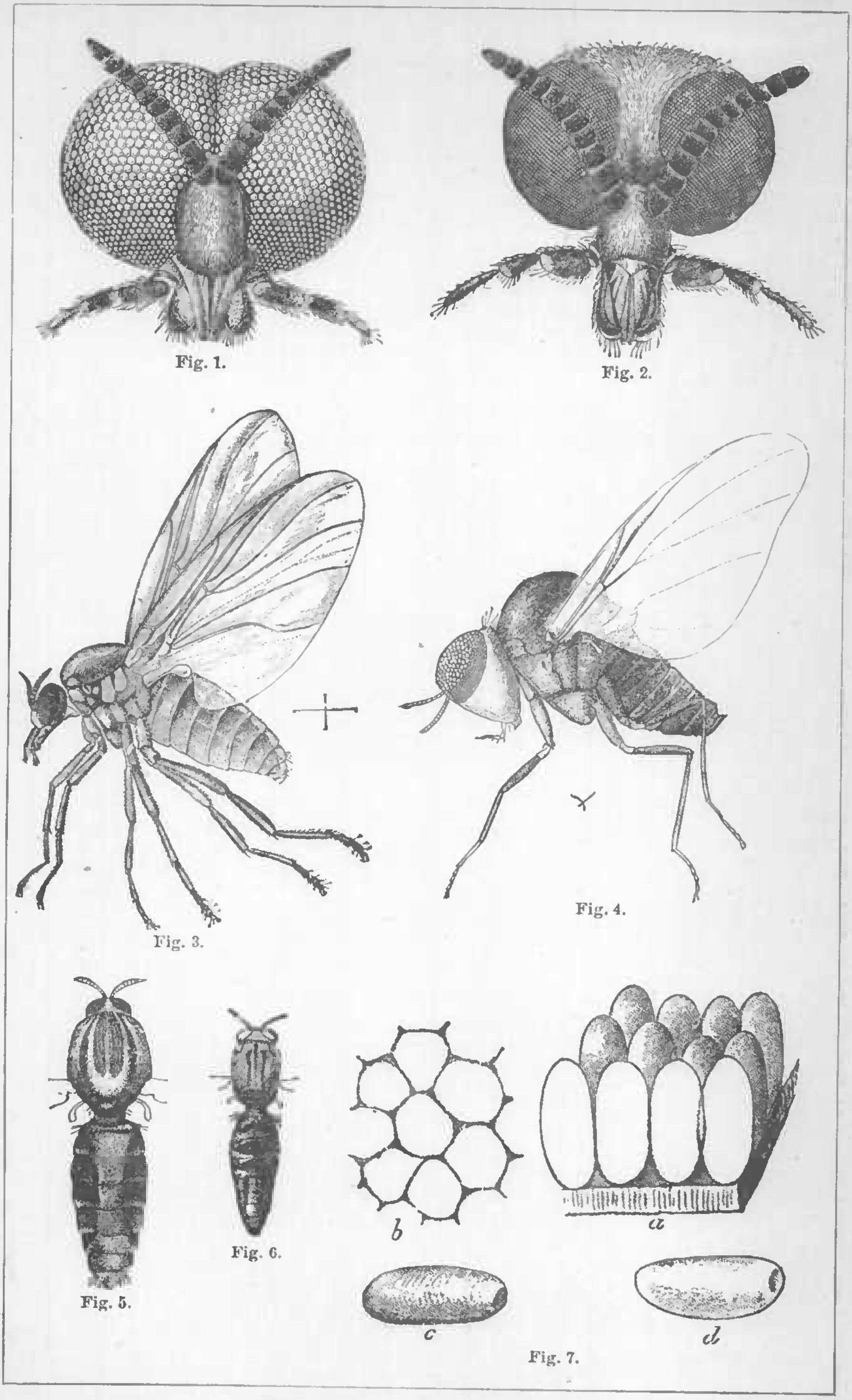


Fig. 4.

THE SOUTHERN BUFFALO GNAT AND THE TURKEY GNAT.



THE SOUTHERN BUFFALO GNAT AND THE TURKEY GNAT.

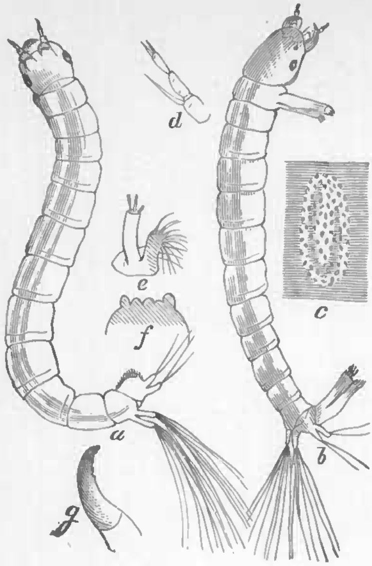
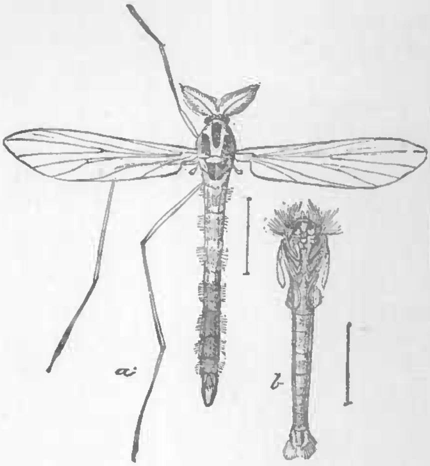


Fig 1.



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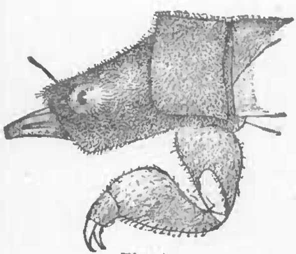


Fig. 4.

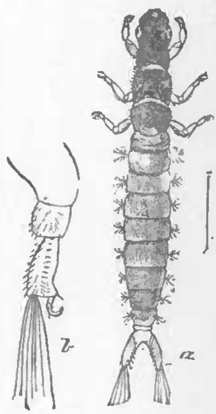


Fig. 3.

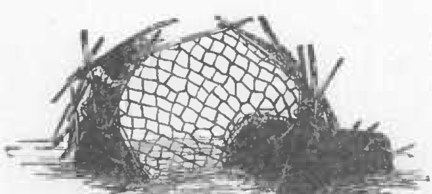


Fig. 5.

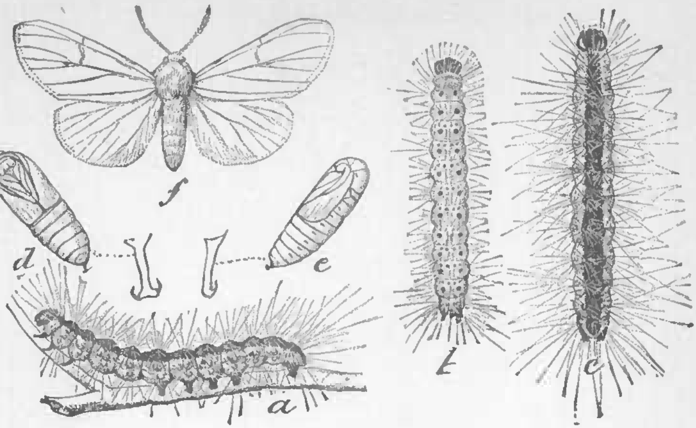


Fig. 1.

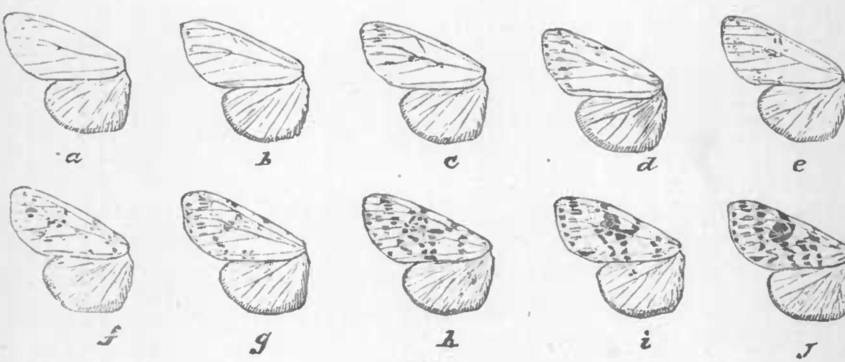


Fig. 2.

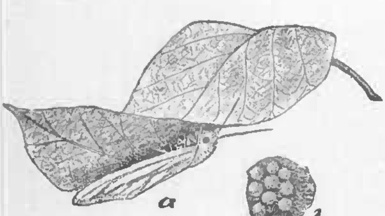


Fig. 3.

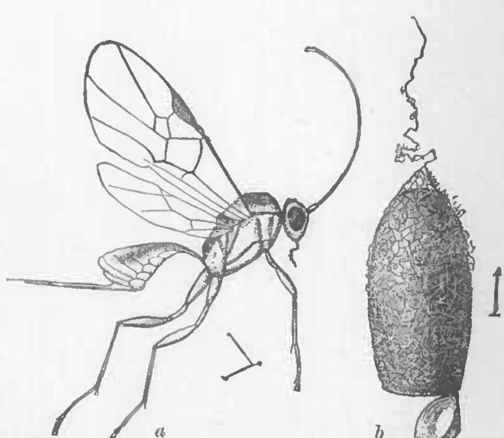
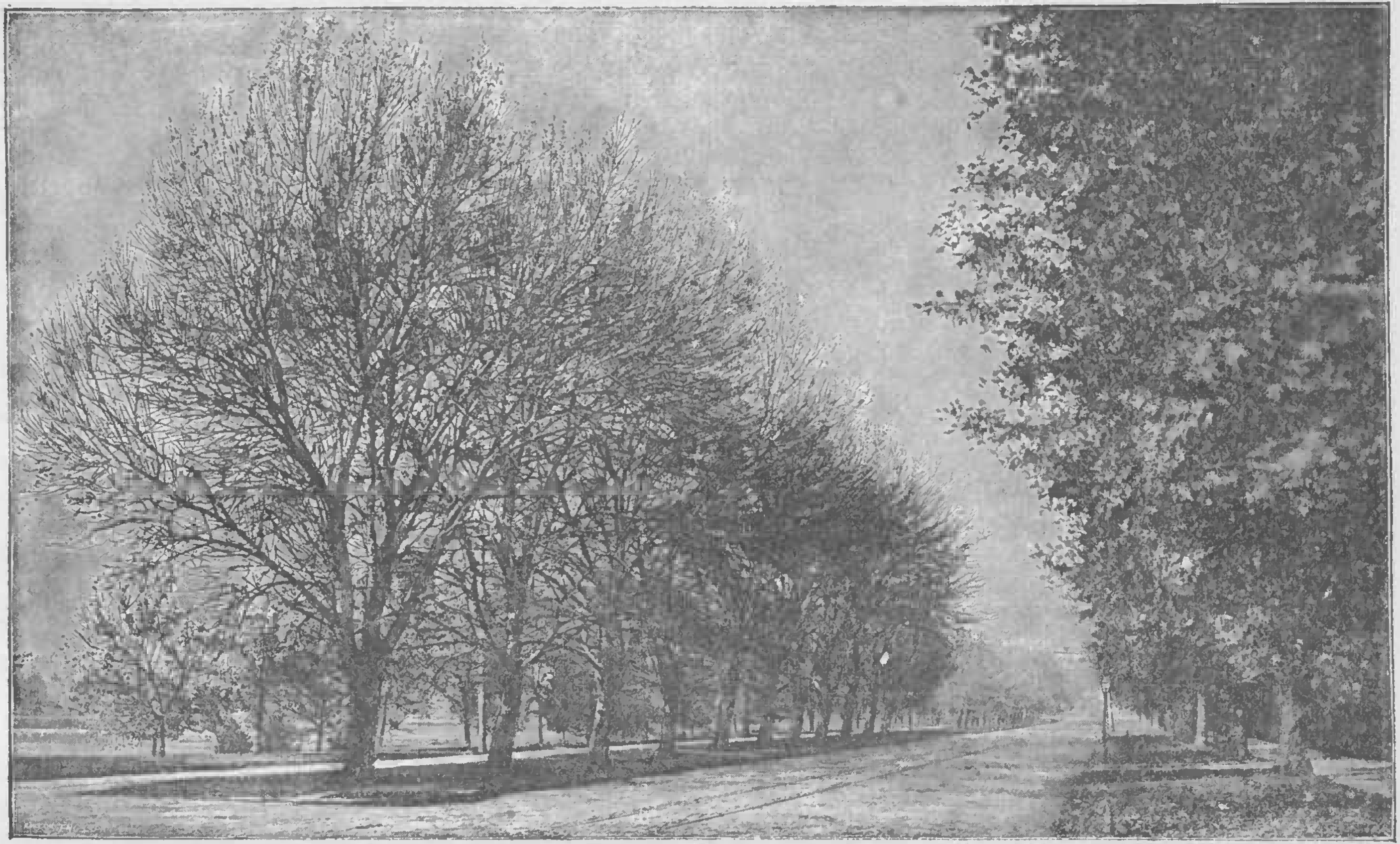


Fig. 4.

THE FALL WEB-WORM.



RAVAGES OF THE WEB-WORM ON POPLARS ON ONE SIDE OF A WASHINGTON STREET AND EXEMPTION OF MAPLES ON THE OTHER.

REPORT OF THE CHIEF OF THE BUREAU OF ANIMAL INDUSTRY.

SIR: I have the honor to transmit herewith my report, which contains a statement of the more important work accomplished by the Bureau of Animal Industry during the past year. For many interesting details of this work, and for the reports of the Agents and Inspectors, I must refer you to the Third Annual Report of the Bureau of Animal Industry.

D. E. SALMON,
Chief of the Bureau of Animal Industry.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

PROGRESS OF PLEURO-PNEUMONIA AND ACTION TAKEN IN REGARD TO IT.

KENTUCKY.

At the time my last annual report was submitted the outbreak of pleuro-pneumonia in Kentucky, which began in 1884, was still in progress. A portion of the history of this outbreak is recorded in the reports of the Bureau of Animal Industry for 1884 and 1885. When first discovered the plague was confined to one herd. There was an attempt to maintain quarantine by the force of public opinion in the absence of any specific statutes, but, as was to be expected, it was not successful. The danger of the extension of the contagion was such, that on June 15, 1885, the infected premises were declared in quarantine by authority of the State board of health. At that time an additional herd was found infected and included in the regulations, a copy of which will be found on page 35 of the Report of the Bureau of Animal Industry for 1885. By request of the board, an inspector of the Bureau was stationed at Cynthiana to watch the results of this quarantine. November 16, 1885, he reported that the disease had been found at 6 places in Cynthiana, at 3 places in the Indian Creek neighborhood, 3½ miles east of Cynthiana, and at one place near the Pendleton County line, 13 miles north of Cynthiana.

Early in March, 1886, the legislature of Kentucky enacted a law authorizing the State board of health to slaughter the infected cattle, and appropriated money to compensate the owners. The slaughter began on March 15, and on March 27 I received official notification that all exposed animals had been slaughtered. I give below a copy of a letter from the secretary of the board to the Chief of the Bureau of Animal Industry, which shows his estimate of the value of the services rendered by this Department in suppressing the malady:

BOWLING GREEN, KY., *March* 27, 1886.

SIR: I have the honor to inform you, as Dr. Wray has done in detail, that in the execution of the recently enacted law in relation to contagious and infectious diseases of cattle this board has exterminated contagious pleuro-pneumonia in this State by the slaughter of all animals which have been exposed to that disease and rigidly quarantined all infected premises.

In consequence of the foregoing facts, we hope to have the influence of your Department in securing the removal of the restrictions now imposed against Kentucky cattle by most of the Western States.

I desire also to call your attention to the inclosed resolution in regard to Dr. Wray, and to add that there is every reason to believe that but for the timely and efficient aid rendered me by your Department during the last year the disease would have made such headway, and the sum of money required for its extirpation would have been so large, that our legislature could not have been induced to extirpate the disease. I inclose a copy of our law and quarantine blanks.

Respectfully, yours,

J. N. McCORMACK,
Secretary.

Dr. D. E. SALMON,
Chief of the Bureau of Animal Industry, Washington, D. C.

Resolved, That the thanks of the State board of health of Kentucky be, and are hereby, tendered to Dr. W. H. Wray for the faithful, efficient, and intelligent manner in which he has discharged his important duties in the management of the outbreak of contagious pleuro-pneumonia in Harrison County.

A true extract from the proceedings of the board.

J. N. McCORMACK, *Secretary.*

Dr. Wray furnished the following statement, showing the number of infected herds and animals in the vicinity of Cynthiana, and the results of the disease at each place:

Previous to August 4, 1885, four animals in the Frisbie & Lake herd had died and 14 sick ones had been slaughtered. From and after August 4 the extent of the disease and the disposition of the animals is seen in the following table:

Owner of herd.	Increase since August 4, 1885.	Number that died.	Number killed that were sick.	Number killed that were exposed.	Number sold to butcher.	Number in herd.
Frisbie & Lake	17	1	38	65	......	87
W. T. Handy	3	1	9	7	5	19
Mrs. Roberts	......	......	1	......	......	1
Mr. Woolwinder	......	......	......	......	1	1
Irving Cox	1	......	2	1	11	13
J. S. Withers	......	1	1	......	......	2
M. Bridwell	1	......	1	4	......	4
George Edsall	......	......	......	......	2	2
T. J. Megibben	......	......	1	3	......	4
W. S. Morland	......	......	1	......	......	1
D. N. Brannock	......	......	*3	*14	......	17
Jos. Stephens	......	......	1	......	......	1
O. Slade	......	......	1	......	......	1
I. N. Slade	......	......	......	1	......	1
P. Barhart	......	......	......	......	1	1
J. W. Lang	......	......	......	......	1	1
J. D. Feeback	......	......	1	......	......	1
M. Rule	......	......	......	......	1	1
T. J. Moffitt	......	......	1	......	......	1
A. Fitzwater	......	......	......	2	......	2
A. W. Lydick	......	......	......	1	......	1
Mr. Kaufman	......	......	......	1	......	1
J. Cronin	......	......	1	2	......	3
Mrs. Stewart	......	......	......	1	......	1
D. Shea	......	......	......	3	......	3
James Brenan	......	......	......	1	......	1
I. T. Martin	......	......	......	1	......	1
W. E. Slade	1	......	......	2	......	1
James Doyle	......	......	......	1	......	1
Mr. Sullivan	......	......	......	2	......	2
W. S. Wall	......	1	......	......	......	1
T. Robertson	......	......	1	......	......	1
F. Reynolds	......	......	......	2	......	2
Total August 4, 1885	23	4	63	114	22	180
Total increase	......	......	......	......	......	23
Grand total	......	......	......	......	......	203

*Killed by mob.

Dr. Wray remained at Cynthiana until June 22, or about three months after the last affected animal was slaughtered, and no case of this disease was discovered during that time. I have recently had reliable reports from that vicinity, and I am satisfied that no case of pleuro-pneumonia has occurred since the slaughter of the infected cattle in March.

This outbreak in Kentucky by itself indicates the great superiority of a method which secures the prompt extirpation of the contagion over any temporizing measures, the effect of which is to preserve instead of to destroy it. As soon as pleuro-pneumonia was known to exist in Kentucky the other States of the Union quarantined against Kentucky cattle, and the enormous commerce in these animals was prostrated. The local quarantine measures were looked upon by the authorities of other States as an insufficient guarantee of the safety of cattle from Kentucky, and therefore no bovine animals were allowed admittance from there except under rigid and burdensome restrictions. These restrictions, maintained for nearly two years, are estimated to have caused a loss to the cattle-breeders of the State of from $10,000,000 to $12,000,000; a loss which would have been entirely prevented if there had been authority for this Department to cause the prompt destruction of the infected herds when the plague was first discovered.

ILLINOIS.

In September, 1886, pleuro-pneumonia was found by the State veterinarian to exist among cattle in the city of Chicago and vicinity. It was first discovered on the farm of John Carne, at Ridgeland, near Austin, a station on the Chicago and Northwestern Railroad, 6 or 7 miles from Chicago. The diseased animal was killed September 12, and the *post mortem* examination showed conclusively that it was affected with lung-plague. This cow had been on the premises a long time, but she had recently been exposed to an ailing cow that Mr. Carne had taken for trial with the intention of purchasing. This sick cow was brought on the place by Silas Palmer, a cow dealer, who had pastured her for some time previous on the Harvey farm, near Humboldt Park. It was represented to Mr. Carne that the cow was suffering from bad treatment and would soon recover. After doctoring it for two or three weeks with no success the dealer was notified that it was not wanted, and he removed it.

In an attempt to trace the contagion the Harvey farm was visited by the State veterinarian September 15 and 16, and he found there 250 head of cattle, among which were 8 affected with pleuro-pneumonia. These animals were at once quarantined. An investigation of the history of the disease at this farm led to the conclusion that it had been introduced by a herd of 38 cows brought there to pasture by a milkman named Quinn, who had recently removed his animals from the Phœnix Distillery stables. This led to an examination of the cattle in the distillery stables, and to the discovery that many of them were affected with pleuro-pneumonia.

The Phœnix stables were quarantined September 19. They contained 1,185 animals, of which 297 were Western steers and bulls which had been placed there to fatten September 15 by Nelson Morris. The remainder of the animals were milch cows, belonging to a number of different owners. The stables of the Chicago and Empire Distil-

leries were quarantined the same day. They contained respectively 496 and 207 animals. The Shufeldt stables contained 985 animals, and were quarantined September 20.

A further examination of the cattle of Mr. Carne September 18 showed that another one was sick, and this, together with two exposed ones, was slaughtered. The day before, September 17, two sucking calves were found affected at the Harvey farm and were slaughtered.

September 20 two sick cows were killed at the Phœnix and found affected with pleuro-pneumonia. September 22 the Chief of the Bureau of Animal Industry, in company with the State veterinarian and members of the State Live-Stock Commission, made an investigation at the Phœnix and Shufeldt stables, to satisfy himself as to the nature of the disease. The examination was made on one animal that had died and two that were killed at the former stable, and upon one that was killed and one found dead at the latter. All were undoubtedly affected with contagious pleuro-pneumonia.

The milkmen at first denied the existence of any disease among their cattle, but when the evidence became too strong to be longer contested it was admitted that they had recognized the presence of a lung disease in 1884. They at first attributed it to chemicals used in the mash by the distillers, also to feeding the slop too hot, but they finally concluded it was contagious pleuro-pneumonia, and were practicing inoculation to lessen the mortality.

The progress of the plague after quarantine may be seen from the following notes made from day to day by the veterinarians. A part of these were kindly furnished by Dr. Casewell, State veterinarian, and the remainder were collected by Dr. Trumbower, inspector of the Bureau of Animal Industry. It is to be borne in mind that the mortality was probably lessened by the practice of inoculation:

September 23: 1 slaughtered and 1 found dead at the Phœnix; 1 slaughtered and 1 found dead at the Shufeldt.

September 24: 2 slaughtered at the Chicago.

September 25: 1 slaughtered and 1 found dead at the Phœnix.

September 27: 1 slaughtered at the Chicago and 2 found dead at the Phœnix.

September 30: 1 dead at the Shufeldt.

October 2: 2 dead at the Phœnix.

October 3: 1 dead at the Phœnix.

October 4: 1 dead at the Chicago and 2 dead at the Phœnix.

October 5: 3 dead and 1 slaughtered at the Phœnix; 1 dead at the Chicago; 1 dead at the Empire.

October 6: 1 dead at the Phœnix; 1 dead at the Chicago.

October 8: 1 slaughtered at the Chicago.

October 10: 1 slaughtered and 1 dead at the Chicago; 1 dead at the Phœnix.

October 11: 1 dead at the Phœnix.

October 12: 1 dead at the Shufeldt.

October 13: 2 dead at the Chicago; 1 dead at the Shufeldt.

October 16: 1 cow and 1 steer dead at the Phœnix (this was the first steer that died of pleuro-pneumonia out of the lot placed in these stables September 15); 1 dead at the Shufeldt; 10 cows were taken at the Shufeldt and slaughtered at the abattoir; lungs found healthy.

October 17: 1 slaughtered and 1 dead at the Chicago; 1 cow and 2 bulls from the Phœnix slaughtered, lungs healthy.

October 18: 1 cow at the Shufeldt slaughtered, affected; 4 slaughtered from the Phœnix, lungs healthy; 7 slaughtered from the Chicago, lungs healthy.

October 19: 2 cows and 1 steer dead at the Phœnix; 1 dead at the Chicago; killed 14 cows from the Phœnix, lungs healthy.

October 20: 1 cow and 2 steers dead at the Phœnix, only 1 of the latter affected with lung-plague; 2 healthy cows from the Phœnix slaughtered; 1 dead at the Chicago.

October 21: 2 dead at the Shufeldt; 1 dead at the Chicago; 3 dead at the Phœnix; slaughtered 2 healthy cows from the Phœnix.

October 22: 2 steers dead at the Phœnix; 1 dead at the Shufeldt; slaughtered 5 affected animals at the Shufeldt.

October 23: 1 dead at the Chicago; 1 dead at the Shufeldt.

October 24: 2 dead at the Chicago and 1 affected animal slaughtered.

October 25: Slaughtered 11 at the Chicago, all healthy; 1 cow and 2 steers dead at the Phœnix; slaughtered 16 cows from the Phœnix, all healthy.

October 26: 1 steer and 1 cow dead at the Phœnix; slaughtered 24 cows from the Phœnix, 3 affected; 1 dead at the Shufeldt.

October 27: Slaughtered 14 cows and 2 calves from the Phœnix, lungs healthy; 1 cow and 1 bull dead at the Phœnix.

October 28: killed 2 cows at the Shufeldt, 1 affected with pleuro-pneumonia and 1 with chronic indigestion.

October 29: 1 dead at the Shufeldt.

October 30: 1 affected killed and 1 died from choking at the Shufeldt; 1 affected steer killed and 3 steers dead at the Phœnix.

October 31: 1 dead at the Shufeldt; 1 dead at the Phœnix.

November 1: Slaughtered 3 at the Shufeldt, lungs healthy; 1 dead at the same place; slaughtered 14 cows from the Phœnix, 5 of which were affected.

November 2: 1 dead at the Phœnix.

November 3: Slaughtered 18 cows from the Phœnix, 5 affected; 1 steer and 2 cows dead at the Phœnix.

November 4: 1 cow dead at the Shufeldt; killed 1 cow, lungs healthy; killed 5 at the Chicago, lungs healthy; 1 steer dead at the Phœnix.

November 5: 2 cows and 1 steer dead at the Phœnix; 1 cow dead at the Shufeldt.

November 6: 1 steer dead at the Phœnix.

November 7: 1 steer dead at the Phœnix; 1 cow dead at the Shufeldt.

November 8: 1 slaughtered at the Shufeldt, affected; 1 steer dead at the Phœnix.

November 9: slaughtered 14 from the Shufeldt, 9 affected.

November 10: 1 steer and 1 bull dead at the Phœnix; slaughtered 19 from the Shufeldt, 2 affected.

November 11: 2 steers dead at the Phœnix.

November 12: 1 cow dead at the Phœnix.

November 13: 1 cow dead at the Shufeldt; visited Harvey farm and found 2 new cases.

November 14: 2 steers dead at the Phœnix; 1 cow dead at the Shufeldt; examined 45 cows, 2 affected.

November 15: Slaughtered 2 cows from the Phœnix, both affected; also 11 from the Shufeldt, 4 affected.

November 16: 2 cows dead at the Shufeldt; 2 cows dead at the Phœnix.

November 17: 1 steer dead at the Phœnix; 1 cow killed at the Chicago, affected.

November 18: 1 cow condemned at the Phœnix.

November 19: Killed 6 cows from Phœnix, 2 affected; 1 steer dead at same place.

November 21: 1 cow dead at the Shufeldt.

November 22: 1 steer dead at the Phœnix; 1 cow dead at the Shufeldt.

November 24: 1 cow slaughtered from the Shufeldt, lungs healthy.

November 25: Slaughtered 1 diseased cow at Ridgeland.

November 26: 3 cows dead at the Shufeldt, 1 of which died from choking.

November 27: 1 cow dead at the Shufeldt; 1 cow dead at the Chicago; slaughtered 12 cows from the Phœnix, 1 of which was affected.

November 30: 1 cow and 1 steer dead at the Phœnix; slaughtered 5 affected steers and bulls at same place.

November 28: Slaughtering was begun on a larger scale, in order to empty the distillery stables as soon as possible. The figures given below, which show the proportion of slaughtered animals that were more or less affected with pleuro-pneumonia, are of great interest, because they demonstrate the advisability of slaughtering all animals once exposed to the contagion. Many of the affected cattle presented no symptoms of disease before slaughter, but the condition of their lungs was such

as to make it very certain that they were capable of disseminating the contagion for an indefinite period. The record is as follows:

Date.	Number slaughtered.	Number affected.
November 28	237	85
29	183	106
30	143	72
December 1	179	59
2	137	83
3	185	56
6	223	130
7	198	126
8	166	86
9	205	100
10	85	23
14	231	69
15	51	21
16	48	24
Total	2,271	1,031

Of the 297 steers and bulls which were put in the Phœnix stables September 15 by Mr. Morris, 37 affected with pleuro-pneumonia died or were killed for examination previous to the 28th of November. Three others died of Texas fever and 1 cripple was killed up to the same date. November 29 and 30 and December 1, 244 of the remainder were slaughtered, of which 182 were found affected.

One of the inspectors of the Bureau of Animal Industry was stationed at the rendering company's platform from October 19 to November 30, to make *post mortem* examination of all cows coming there from the city of Chicago. During that time he examined 19 cows, of which 6 had died of lung-plague.

The following table shows the number of cattle placed in quarantine in Chicago and vicinity from October 13 to November 30, all being in private herds and stables, and the greater part of which were quarantined because of exposure to affected cattle on the various commons about the city.

Date.	Number of herds.	Number of cattle.	Number affected.	Remarks.
October 13	1	66	Several	Two have since died.
15	10	77	12	
16	10	41	1	
18	40	104	3	
19	30	67	3	
20	*6	6		Quarantined for exposure.
21	*10	26	15	
22	*17	17		Do.
23	2	38		Do.
25	*2	3		Do.
26	2	2	1	One died November 2.
27	15	34	8	
28	15	29	1	
29	15	20	2	
30	*13	13	1	
November 1	*11	11	1	
2	*8	8	1	Recovered.
3	*13	13	1	
4	9	33	1	Do.
5	7	11		Quarantined for exposure.
6	1	66		Do.
10	1	1		Do.
19	17	48		Do.
20	9	20		Do.
23	16	53		Do.
24	22	80		Do.
26	18	49		Do.
27	11	103		Do.
30	1	2		Do.

*Stables.

The above is a brief *résumé* of the work that has been accomplished in Chicago by co-operation between the State Live-Stock Commission and the Bureau of Animal Industry since the discovery of the recent outbreak of pleuro-pneumonia. As there was great apprehension that cattle would be removed from the distillery stables and disseminate the disease in Illinois and other States, a guard of deputy sheriffs was placed at each stable and at the Harvey farm. Two were on duty at each place during the day and four at night. Besides these, two men were employed to count the cattle daily, in order that any decrease in number would be at once discovered. Six veterinary inspectors were also ordered to Chicago to inspect the city and learn to what extent the contagion had progressed outside of the distillery stables.

The following rules and regulations for co-operation were certified to the governor of Illinois and accepted by him:

Rules and regulations for co-operation between the U. S. Department of Agriculture and the authorities of the several States and Territories for the suppression and extirpation of contagious pleuro-pneumonia of cattle.

Recent acts of Congress make it the duty of the Commissioner of Agriculture to prepare rules and regulations for the suppression and extirpation of the contagious pleuro-pneumonia of cattle, and authorize expenditures for investigation, disinfection, quarantine, and for the purchase of diseased animals for slaughter. The following are the sections bearing upon this subject:

"SEC. 3. That it shall be the duty of the Commissioner of Agriculture to prepare such rules and regulations as he may deem necessary for the speedy and effectual suppression and extirpation of said diseases, and to certify such rules and regulations to the executive authority of each State and Territory, and invite said authorities to co-operate in the execution and enforcement of this act. Whenever the plans and methods of the Commissioner of Agriculture shall be accepted by any State or Territory in which pleuro-pneumonia or other contagious, infectious, or communicable disease is declared to exist, or such State or Territory shall have adopted plans and methods for the suppression and extirpation of said diseases, and such plans and methods shall be accepted by the Commissioner of Agriculture, and whenever the governor of a State or other properly constituted authorities signify their readiness to co-operate for the extinction of any contagious, infectious, or communicable disease in conformity with the provisions of this act, the Commissioner of Agriculture is hereby authorized to expend so much of the money appropriated by this act as may be necessary in such investigations, and in such disinfection and quarantine measures as may be necessary to prevent the spread of the disease from one State or Territory into another." (Approved May 29, 1884.)

BUREAU OF ANIMAL INDUSTRY.

"For carrying out the provisions of the act of May 29, 1884, establishing the Bureau of Animal Industry, $100,000; and the Commissioner of Agriculture is hereby authorized to use any part of this sum he may deem necessary or expedient, and in such manner as he may think best, to prevent the spread of pleuro-pneumonia, and for this purpose to employ as many persons as he may deem necessary, and to expend any part of this sum in the purchase and destruction of diseased animals whenever in his judgment it is essential to prevent the spread of pleuro-pneumonia from one State into another." (Approved June 30, 1886.)

In accordance with these laws I hereby certify the following rules and regulations for co-operation between the Department of Agriculture and the authorities of the several States and Territories, which I deem necessary to insure results commensurate with the money expended:

INSPECTION.

1. The necessary inspectors will be furnished by the Bureau of Animal Industry of the Department of Agriculture.

2. The properly constituted inspectors of the Bureau of Animal Industry which are assigned to the respective States are to be authorized by proper State authorities to make inspections of cattle under the laws of the State; they are to receive such protection and assistance as would be given to State officers engaged in similar work, and shall be permitted to examine quarantined herds whenever so directed by the Commissioner of Agriculture or the Chief of the Bureau of Animal Industry.

3. All reports of inspections will be made to the Bureau of Animal Industry, and a copy of these will then be made and forwarded to the proper State authorities. When, however, any inspector discovers a herd infected with contagious pleuro-pneumonia, he will at once report the same to the proper State authority as well as to the Bureau of Animal Industry.

4. The inspectors, while always subject to orders from the Department of Agriculture, will cordially co-operate with State authorities, and will follow instructions received from them.

QUARANTINE.

5. When contagious pleuro-pneumonia is discovered in any herd, the owner or person in charge is to be at once notified by the inspector, and the quarantine regulations of the State in which the herd is located are to be enforced from that time. The affected animals will be isolated, when possible, from the remainder of the herd until they can be properly appraised and slaughtered.

8. Quarantine restrictions once imposed are not to be removed by the State authorities without due notice to the proper officers of the Department of Agriculture.

9. The period of quarantine will be at least ninety days, dating from the removal of the last diseased animal from the herd. During this period no animal will be allowed to enter the herd or to leave it, and all animals in the herd will be carefully isolated from other cattle.

When possible, all infected herds are to be held in quarantine and not allowed to leave the infected premises except for slaughter. In this case fresh animals may be added to the herd at the owner's risk, but are to be considered as infected animals and subjected to the same quarantine regulations as the other members of the herd.

SLAUGHTER AND COMPENSATION.

10. All animals affected with contagious pleuro-pneumonia are to be slaughtered as soon after their discovery as the necessary arrangements can be made.

11. When diseased animals are reported to the State authorities, they shall promptly take such steps as they desire to confirm the diagnosis. The animals found diseased are then to be appraised according to the provisions of the State law, and the proper officer of the Bureau of Animal Industry (who will be designated by the Commissioner of Agriculture) notified of the appraisement. If this representative of the Bureau of Animal Industry confirms the diagnosis and approves the appraisement, the Department of Agriculture will purchase the diseased animals of the owner and pay such a proportion of the appraised value as is provided for compensation in such cases by the laws of the State in which the animals are located when they are condemned and slaughtered by State authority.

DISINFECTION.

12. All necessary disinfection will be conducted by the employés of the Bureau of Animal Industry.

INOCULATION.

13. Inoculation is not recommended by the Department of Agriculture, and it is believed that its adoption with animals that are to be afterwards sold to go into other herds would counteract the good results which would otherwise follow from the slaughter of the diseased animals. It will not be practiced in this State.

The co-operation of governors, of State live stock commissions, and of other officers who may be in charge of the branch of the service provided for the control of the contagious diseases of animals in the States where pleuro-pneumonia exists, is earnestly requested under these rules and regulations, which have been framed with a view of securing uniform and efficient action throughout the whole infected district. It is hoped that with a vigorous enforcement of such regulations the disease may be prevented from extending beyond its present limits, and may be in time entirely eradicated.

NORMAN J. COLMAN,
Commissioner of Agriculture.

WASHINGTON, D. C., *August* 2, 1886.

By virtue of the authority imposed upon me as governor of the State of Illinois I hereby accept the above rules and regulations, and the proper officers of this State will co-operate with the United States Department of Agriculture for their enforcement.

RICHARD J. OGLESBY.

SPRINGFIELD, ILL., *September* 27, 1886.

The Department has not purchased diseased animals for slaughte in Illinois, because the law of that State makes it the duty of the live-stock commissioners to slaughter such animals at once without compensation. With this law on the statute-books of the State, and with no apparent reason why it should not be enforced, it was not "essential to prevent the spread of pleuro-pneumonia from one State into another" that any part of the appropriation should be used in Illinois to purchase diseased animals for slaughter. This conclusion was confirmed by the desirability of adopting only such measures as conform with the statutes of the States in which the work is being done, so long as our only authority to enforce regulations within the States must be obtained from State legislation.

PROGRESS OF CO-OPERATION WITH OTHER INFECTED STATES.

Co-operation with the other infected States has not progressed as satisfactorily as was anticipated. In the latter part of July a conference was held in Philadelphia, at which were present the Chief of the Bureau of Animal Industry, and representatives of the States of New Jersey, Pennsylvania, Delaware, and Maryland. In formulating the rules and regulations for co-operation as much consideration was given for the views expressed at that conference as was consistent with the object that was to be accomplished. It was understood at the time that the four States there represented would cooperate with this Department under any reasonable rules and regulations.

Rules and regulations were issued on August 2, and sent to the governors of the interested States for their acceptance. With the exception of the following rules, which were omitted or changed in the case of Illinois, they were identical with those given above as accepted by that State:

6. To insure a perfect and satisfactory quarantine, a chain fastened with a numbered lock will be placed around the horns, or with hornless animals around the neck, and a record will be kept showing the number of the lock placed upon each animal in the herd.

7. The locks and chains will be furnished by the Department of Agriculture, but they will become the property of the State in which they are used, in order that any one tampering with them can be proceeded against legally for injuring or embezzling the property of the State.

8. Quarantine restrictions once imposed are not to be removed by the State authorities without the consent of the proper officers of the Department of Agriculture.

INOCULATION.

13. Inoculation is not recommended by the Department of Agriculture, and it is believed that its adoption with animals that are to be afterwards sold to go into other herds would counteract the good results which would otherwise follow from the slaughter of the diseased animals. It may, however, be practiced by State authorities under the following rules:

14. No herds but those in which pleuro-pneumonia has appeared are to be inoculated.

15. Inoculated herds are to be quarantined with lock and chain on each animal, the quarantine restrictions are to remain in force so long as any inoculated cattle survive, and these animals are to leave the premises only for immediate slaughter.

16. Fresh animals are to be taken into inoculated herds only at the risk of the owner, and shall be subject to the same rules as the other cattle of the inoculated herd.

17. The Chief of the Bureau of Animal Industry is to be promptly notified by the State authorities of each herd inoculated, of the final disposition of each member of the herd, of the *post mortem* appearances, and of any other facts in the history of the herd which may prove of value.

The State of New York was not represented at the conference, as the State veterinarian, Prof. James Law, was then attending to some business in the Western States. After returning, however, he gave it as his opinion that, with the large number of infected herds known to exist on Long Island and in the city of New York and vicinity, it would be unwise to attempt to control the plague with the present small appropriation.

The governor of New Jersey has not accepted the rules, and it appears that the obstacles to co-operation were Rules 8 and 15. The objection to Rule 8 was removed by an offer from this Department to change the reading from "without the consent of the proper officers of the Department of Agriculture" to "without due notice to the proper officers of the Department of Agriculture." This concession was also made to the State of Illinois, but the experience of the last four months leads me to the opinion that it would be wiser for the Department to adhere to the original reading. State authorities often have very different ideas from those entertained by the officers of this Department as to the time when it is safe to remove quarantine restrictions. They consequently object to restrictions which they cannot remove at will. On the other hand, if the National Government appropriates money to pay the expense of this work, there certainly should be some guarantee that the proper regulations are enforced.

The objection to Rule 15 still stands in the way of co-operation with New Jersey. The State authorities have adopted the practice of inoculation, and release the inoculated herds from quarantine after a short period of isolation. After carefully considering the question and all the scientific evidence bearing upon it, I am of the opinion that it is useless to attempt to eradicate pleuro-pneumonia in States where inoculation is practiced and where inoculated animals are afterwards allowed to mingle with the cattle of other herds. The money expended for the purchase of diseased animals for slaughter under such conditions is consequently largely wasted.

The State authorities of New Jersey, however, have been assisted by employing one or more veterinarians nearly the whole time, whose duty it has been to investigate reported outbreaks of disease and give such aid as was needed in inspection and in enforcing the State quarantine regulations. Thirty-one infected herds have been reported from this State, containing 530 animals, of which 42 were diseased.

The governor of Pennsylvania has also failed to accept these rules and regulations. His reasons for not acting on them are unknown to me. The governor's agent in charge of the pleuro-pneumonia work raised some objections to Rule 15, but admitted that its enforcement would make no great difference to the State. Inoculation is practiced by the Pennsylvania authorities also, but with the small number of outbreaks reported it would certainly be advisable to slaughter all diseased and exposed animals and thus rid the State of the plague at once.

Virginia is the only remaining State infected with pleuro-pneumonia where the authorities have not accepted the rules and regulations. The attention of the governor has been called to the desirability of eradicating the disease from the State, but up to the present he has taken no action.

The governors of Delaware and Maryland have accepted the rules and regulations as issued, and without modification of any kind. No cases of pleuro-pneumonia have been reported from Delaware since such acceptance.

Co-operation with authorities of the State of Maryland has been more satisfactory than with those of any other State. The local laws are good, and the work has been very largely in the hands of the inspectors of this Department. The number of infected herds reported from this State is 196, containing 2,277 animals, of which 705 were diseased. Dr. Wray, the inspector who has been in charge of the work in Maryland since September 20, reported under date of December 7 that since the former date 122 herds, containing 1,354 animals, had been put in quarantine, and that 92 herds, containing 1,089 animals, were still held under such restrictions. Since July 1 this Department has purchased and slaughtered in Maryland 308 diseased cattle, for which $7,069 was paid, being an average of about $23 per head.

In Maryland the quarantine has been made very efficient by placing a chain, fastened with a numbered lock, around the horns, or, with hornless cattle around the neck, of every exposed animal. This has prevented the substitution of one animal for another, and it has also led to the prompt detection of any quarantined cattle which have been allowed to stray beyond the boundaries of the infected premises. The sick animals have been promptly slaughtered, and it is believed that the good effects of this work are already seen in the decreased number of new herds infected. In a number of cases where infected herds have been of unusual danger to surrounding cattle this Department has purchased and destroyed the sick animals, and the State has then condemned and slaughtered the remainder of the herd, thus entirely eradicating the disease at once. Unfortunately the State appropriation has not been large enough to do this in as many cases as seemed desirable.

No recent investigations have been made in Pennsylvania. The governor's agent, Mr. T. J. Edge, reports that during the year ending November 30, 1886, 128 diseased animals were condemned and slaughtered.

INVESTIGATIONS OF SWINE DISEASES.

In view of the results of investigations which have shown the existence of two distinct infectious diseases in swine, perhaps of equal virulence and distribution, a change in the nomenclature becomes necessary in order to avoid any confusion in the future. Since these two diseases have been considered as one in the past, and the names swine-plague and hog-cholera have been applied indiscriminately, we prefer to retain both names, with a more restricted meaning, using the name *hog-cholera* for the disease described in the last report as swine-plague, which is produced by a motile bacterium, and applying the name swine-plague to the other disease, the chief seat of which is in the lungs. This change is the more desirable since recent investigations have shown that the latter disease exists in Germany, where it is called swine-plague (*Schweineseuche*).

INVESTIGATIONS OF HOG-CHOLERA.

Some additional biological facts concerning the bacterium which produces the disease.—In the second annual report of the Bureau and the Annual Report of the Department for 1885, the bacterium of hog cholera was quite minutely described, so that no one acquainted with bacteriological investigations would find it difficult to recognize

it when found. The descriptions of size, shape, and mode of staining referred to cover-glass preparations made from the blood and the internal organs directly. These characters change somewhat when the bacterium is cultivated in artificial media. Thus the bacteria grown upon potato vary slightly in size and appearance from those obtained from meat infusions and from nutrient gelatine. On the other hand, their appearance is the same whether the spleen of mice, rabbits, guinea-pigs, or swine be subjected to microscopic examination.

The microbe was characterized as a motile bacterium 1.2 to 1.5 micromillimeters long and .6 micromillimeter broad, growing readily in neutralized and even slightly acid meat infusions, milk, on potato, and gelatine which is not liquefied. During the past year the bacterium has been studied very carefully, with a view to determine the best means of preventing its multiplication, and thus preventing the spread of the disease itself. The conclusions arrived at are given in full below, but will be summarized from a practical point of view in the chapter on prevention.

Growth of the bacterium in simple hay infusion.—This was prepared by allowing finely cut hay to soak in water for three or four days, filtering off the amber liquid and sterilizing. Two tubes were inoculated with a drop from cultures in meat-infusion peptone at different times. In both the following features were observed: There was a slight turbidity within two days, which did not deepen perceptibly. The bacteria were somewhat larger than in more nutritive liquids. In the shorter forms there could be seen at each extremity more refrangent spherical masses, while the central portions of the rod seemed empty. Longer rods contained three or four of these bodies. When stained they appeared darker than the rest of the rod. They were consequently not spores, but very probably masses of protoplasm, which had contracted into these globules, and which indicated a degeneration of the bacteria. There were also forms present which were beaded, club-shaped, and distorted.

Though the acid hay infusion is not a suitable medium, yet the bacterium of hog-cholera evidently multiplies in it to some extent, and we may infer that in any organic infusions, such as are formed about pens among the food of swine, the bacterium may multiply under the influence of a hot sun and be afterward taken into the system with the food and water.

Multiplication of the bacterium in water.—The hardiness of this microbe is well illustrated by its capacity for multiplication in ordinary drinking water. To determine this the following experiment was made:

September 8: A culture tube containing very clear Potomac drinking water,* which had been sterilized several weeks previous by a temperature above 110°C., was inoculated from a pure culture of the bacterium. By mixing a given quantity of this water immediately after inoculation with gelatine, and making a plate culture of the same, it was found that the water contained about 26,240 bacteria in 1^{cc}. The water was kept in the laboratory, in which the temperature corresponded closely with that prevailing out-doors. It was examined from time to time on gelatine plates, and the number calculated for 1^{cc}. The following figures give the results obtained:

September 8: 26,240 in 1^{cc} (immediately after inoculation).
September 9: 201,600 in 1^{cc}.
September 10: 1,296,000 in 1^{cc}.
September 11: Too numerous on plate to be counted.
September 13: 2,608,200 in 1^{cc}.
September 15: 1,519,560 in 1^{cc}.
September 17: 1,306,308 in 1^{cc}.
September 29: 83,700 in 1^{cc}.
October 12: 19,125 in 1^{cc}.

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* When drawn this water did not contain more than 100 to 200 bacteria to the cubic centimeter.

October 21: 10,880 in 1cc.
November 18: 225 in 1cc.
December 6: A few bacteria still present, as determined by liquid cultures.
January 4: Seventeen in 1cc.
January 11: No growth on plates.

That the bacterium can be kept alive in clear river water for four months and perhaps longer is a fact very significant in itself. When we consider, moreover, that the added bacteria multiplied so that each individual was represented by ten at the end of five days, the hardiness of the bacterium is very evident. The danger from infected streams into which feces from sick animals find their way is thus proved beyond a doubt.

The effect of simple drying on the bacterium of hog-cholera.—The resistance of this microbe to various agencies, physical and chemical, is likewise of considerable importance in determining the manner of infection, the spread of epidemics, and the possible means within reach of destroying the virus. In order to test its vitality when deprived of moisture the following experiments were carried out:

January 19, 1886: A number of cover-glasses were heated in the Bunsen flame and then placed on a flamed glass plate under a flamed funnel. The mouth of the funnel was plugged with cotton wool to allow desiccation while excluding aerial organisms. When cool a drop from a pure liquid culture of the bacterium was placed on each cover with a pipette, and the whole left in the laboratory at a temperature of 65° to 80° F. The culture used had been prepared January 7 from the fifth spleen culture, hence was twelve days old.

January 21: Two tubes of nutritive liquid inoculated by dropping a cover-glass into each. Both turbid next day, containing the bacterium of hog-cholera only.

January 25: Two tubes inoculated in the same way. Same result next day.

January 28: Two additional tubes receive each a cover-glass. They were still clear on the following day.

January 29: Two tubes inoculated.

January 30: One tube. These five tubes remained permanently clear. In one, inoculated January 29, a fungus had developed from the cover-glass in the bottom of the liquid. This, however, remained clear.

This series placed the death-point of the bacterium between the seventh and the ninth day.

A second series of covers received each one drop from a culture obtained from a mouse which had died from the effect of inoculation. The culture in beef infusion peptone was ten days old. Treated in the same manner as in the preceding experiment, the bacteria were found to resist drying for ten days, when the stock of cover-glasses was exhausted.

To determine whether bacteria in the body of the diseased animal possess a greater power of resistance than those in cultures the following experiments were made: Some bits of the spleen of a pig which was found crowded with the specific bacteria of hog-cholera were dried on sterile cover-glasses as above described, and then dropped into tubes containing beef infusion. Cover-glasses which had been dried for from eight to sixteen days were able to develop pure cultures of the bacterium in the tubes. The stock of covers being exhausted, another series was tried in the same way. The blood of spleen tissue was permitted to dry undisturbed until the seventh day, when the first tube was inoculated. Cover-glasses dropped into cultures on the seventeenth, nineteenth, twentieth, twenty-first, twenty-fourth, and twenty-sixth days left the cultures sterile. Those dropped in on the eighteenth and twenty-second days produced pure cultures of the bacterium. These experiments indicate a greater resistance of the bacterium in spleen tissue, which may live twenty-two days in a dry atmosphere at a temperature of 70° to 80° F.

On May 8 five cover-glasses upon which bits of spleen tissue, known to contain the bacterium of hog-cholera, had been dried under a plugged funnel since March 20, were dropped into tubes of beef infusion. On the following day all tubes were turbid. In one of them *bacillus subtilis* was present. All the others were pure cultures, as determined by microscopical examination. Two of these were tested furthermore on gelatine plates with the same results. This indicates that in the varying temperature of a room desiccation of small bits of tissue (not so large as a pin's head) failed to destroy the bacterium in forty-nine days. In the experiments with dried cultures those ten and eleven days old were chosen, so that if any resist-

ant spore state did form in liquids it would be present. It is highly probable, however, that if cultures but a few days old had been chosen the bacteria would have resisted drying much longer. These experiments give the following results:

A liquid culture eleven days old resisted drying for nine days; another, ten days old, at least ten days. Bacteria in tissue may resist destruction after drying for from twenty-two to forty-nine days.

The method of drying the bacteria on cover-glasses and introducing the latter into liquid does not inform us whether most bacteria die within the same time or whether some resist much longer than others. Hence the following expedient was resorted to, which Koch had introduced in the study of disinfectants: Silk threads sterilized by boiling several times in distilled water were dried and steeped in a beef infusion peptone culture about one week old. The culture containing the threads was allowed to dry in the incubator for one day, then placed in a sterilized bottle plugged with cotton. Each day, beginning with the second, one or two threads were placed in a layer of nutritive gelatine on a glass plate so that the thread was completely covered by the gelatine. Characteristic colonies of the bacterium appeared around the thread within two days, though the plates were usually kept under observation five days. For twenty-one days isolated colonies and groups of colonies appeared in moderate abundance on the threads, when the stock of the latter was exhausted.

In another similar series the threads were laid upon a sterile plate and a twenty-four hours' liquid culture poured upon them and allowed to dry uncovered in the incubator for one day. These threads, still undisturbed on the plate, were placed in the laboratory, covered with a bell glass. On the fifteenth day the testing began, a single thread being placed in the gelatine layer each day for sixteen days. Colonies of the bacterium developed in large numbers until the twenty-second day, when they diminished in number. On the twenty-seventh and twenty-eighth days no colonies appeared. On the three following days a few appeared, when the series was closed.

The bacterium of hog-cholera may therefore remain alive, during continuous desiccation, for from ten days to nearly two months. The variation in the results obtained is no doubt due to the different vitality of the cultures used. The gelatine-plate method is not so delicate a test as the method of liquid cultures, as it would be difficult to tell when the last bacterium died, a single colony under the thread escaping observation very easily. A single bacterium would invariably reveal its presence in a liquid after a time by multiplication. For the same reason the latter method needs greater care; the liquid cultures must be examined microscopically, and if there be any doubt still remaining they must be tested on gelatine; for a single foreign microbe gaining access to the culture tube might introduce an error into the results, which is easily avoided on the gelatine plate by observing the characters of the colonies.

It had been determined by a large number of experiments that cultures of the bacterium of hog-cholera can be sterilized—in other words, that the bacterium itself may be destroyed—by an exposure to 58° C. for from 15 to 20 minutes. To determine whether dried blood or spleen tissue containing the bacterium was more resistant the following experiment was tried:

Spleen pulp from a case of hog-cholera was rubbed upon sterile cover-glasses and allowed to dry under a plugged funnel for 24 hours at a temperature of 65° to 75° F. Four tubes of beef infusion, after a cover-glass had been dropped into each, were exposed to a temperature of 58° C. for 15, 20, 29, and 41 minutes, respectively. These remained permanently sterile, while a fifth tube, which had been inoculated in the same way but not heated, contained on the following day a pure culture of the hog-cholera bacterium. It should be added that each cover-glass contained a considerable number of germs, according to microscopic examination of different parts of the spleen.

The bacterium within the body of the diseased animal cannot therefore be regarded more resistant than when cultivated in liquids.

Effect of boiling water.—Culture tubes containing about 10^{cc} of meat infusion were placed in boiling water until at the boiling-point. They were then removed,

and a sterile cover-glass, upon which a bit of spleen tissue had been drying for five days under a plugged funnel, was dropped into each tube. These were immediately placed in ice water. A preliminary experiment had shown that the temperature in these tubes fell below 40° C. in less than a minute. The spleen had been previously found to contain the bacteria in large numbers. Of four tubes treated in this way two became turbid with the specific bacterium; the others remained sterile.

In a subsequent experiment, four tubes were inoculated near the boiling temperature and one as a check. This latter developed into a pure culture of the bacterium; the heated tubes remained permanently clear. An almost momentary exposure of the dried bacteria is sufficient, therefore, to destroy their vitality.

Resistance to various chemical substances or disinfectants.—In the following experiments on the effect of various agents on the vitality of the bacterium of hog-cholera the methods used by Koch were not adopted, because liquids are far more sensitive to bacteria than solid media. A single colony upon gelatine, the descendants of a single germ, may escape the eye, but the same microbe in a nutrient liquid would cloud it within a few days. There is, to be sure, for this very reason, greater danger in the use of liquid media, since the introduction of a single foreign microbe might lead to the same conclusions as the introduction of a dozen or a hundred, while a few bacteria accidently caught on the gelatine would lead to no errors of interpretation. The results obtained by the method given below were so uniform, the absence of contamination was so constant, that we can recommend it in all similar determinations.

The disinfectant solution was diluted with sterile distilled water in a test-tube or watch-glass previously sterilized by heat. A few drops from a pure culture of the hog-cholera bacterium were mixed with 4^{cc} or 5^{cc} of this dilution, and a minute portion transferred at given intervals, by means of a platinum loop, to culture tubes containing beef broth. These tubes were then placed in a temperature of 95° to 100° F., where they remained from one to four days. Tubes which remained clear at the end of this period were sterile, as shown by numerous tubes which were watched for several weeks.

The experiments given below refer to the active vegetative state of the bacterium in nutrient liquids, as experiments had failed to reveal any other more resistant state. The cultures were, as a rule, but one or two days old. Previous experiments having shown that older cultures are less resistant to heat than recent ones, it was assumed that the vitality is gradually reduced as the culture grows older.

All the tubes about which there seemed the slightest suspicion of impurity were examined microscopically and often on gelatine plates. In all cases the last of a series of inoculated tubes which became turbid was carefully examined. This served as a check upon tubes exposed for a shorter period of time to the action of the disinfectant. The percentage of the solution used indicates the ratio by weight in grams of chemically pure substances to grams of distilled water.

Mercuric chloride was found destructive to the bacterium when diluted in the proportion of 1 : 75000 (.001 1-3 per cent.).

Several drops of a culture were mixed with about 1^{cc} of a .1 per cent. solution, and tubes inoculated from this at the end of 2, 4, 6, 8, and 10 minutes. Tubes remain sterile. To show that the antiseptic effect of the liquid transferred with the platinum loop was *nil*, one of these tubes was inoculated again from another culture. This tube was turbid on the following day.

Five tubes treated in the same way with .05 per cent. solution. All remain sterile.

Five tubes inoculated from a culture exposed for the same periods of time to a .01 per cent. solution. All remain clear.

Five tubes treated as before, using a .005 per cent. solution. Permanently clear.

Five tubes treated as before, using a .002 per cent. solution. All tubes clear excepting the one inoculated after 6 minutes' exposure.

Five tubes inoculated at the end of 5, 10, 15, 20, 25, and 30 minutes after exposure to a .0001 per cent. (1 : 100000). Tubes inoculated after 5 and 10 minutes turbid next day. On the second day all but the one inoculated after 30 minutes turbid and containing pure cultures of the bacterium.

The limit of disinfection for this period of time must therefore lie between 1 : 50000 and 1: 100000; hence 5 tubes were inoculated as above, using a solution of 1 : 75000, at the end of 7, 10, 15, 20, 25, and 30 minutes. All tubes remained clear.

Carbolic acid destroys the bacterium in solutions containing from 1 to 1¼ per cent. of the acid by weight.

Five tubes inoculated after treating the bacterium from a liquid culture with a 1 per cent. solution for 5, 10, 15, 20, and 25 minutes. All turbid on the following day. The two last tubes were also examined on gelatine plates and the cultures found pure.

With a 2 per cent. solution, five tubes inoculated after 10, 15, 20, 25, and 30 minutes remained sterile. The same result with a 1½ per cent. solution. With a 1¼ per cent., tubes inoculated at the end of 7, 10, 15, 20, 25, and 30 minutes remained clear, excepting the first, which contained *bacillus subtilis.*

Passing to a ½ per cent. solution, tubes inoculated at the same intervals became turbid with the bacterium sown. With a ¾ per cent. solution the result was the same.

Passing back to a 1 per cent. solution, tubes inoculated at the same intervals remained sterile.

There seems to be an incompatibility between the first and last series. If we examine the others, however, we must conclude that the limit of disinfection lies between 1 and 1¼ per cent.

Iodine water was prepared by shaking up some iodine in distilled water, which assumed an amber tint. This solution destroyed the bacterium in 15 minutes, as the following experiment shows:

Six tubes were inoculated with bacterium after they had been exposed to the action of the iodine water for 7, 10, 15, 20, 26, and 31 minutes. On the following day the first tube became turbid; on the second the 10-minute tube was turbid and found to be a pure culture of the bacterium sown. The other tubes remained sterile. One of them, inoculated later, showed its capacity for sustaining growth by becoming promptly turbid.

Permanganate of potash.—A series of experiments with this substance, conducted in the manner described above, showed that the bacterium is killed by 15 minutes' exposure to .02 per cent. solution tion (1:5000).

In order to obtain this result a 5 per cent. solution was tried first. Tubes inoculated after an exposure of the virus for 7, 10, 15, 20, 25, and 31 minutes remained permanently clear. One of these tubes, subsequently inoculated with the unaffected virus, was turbid next day. Two and a half per cent., 1 per cent., ½ per cent., ¼ per cent., $\frac{1}{10}$ per cent., and $\frac{1}{20}$ per cent. solutions were tried in the same way. The six tubes used for each solution remained sterile. Finally a $\frac{1}{50}$ per cent. (1 : 5000) was used. Tubes were inoculated after an exposure of the virus for 2, 4, 6, 10, 15, 20, 25, and 30 minutes. On the following day the four first tubes were turbid; the fifth and seventh remained sterile; the sixth and eighth contained a fine bacillus. These two tubes, as was found later, belonged to a lot which, through some carelessness, had not been properly sterilized, and the majority became turbid before use.

Mercuric iodide was found to destroy the bacterium in solution of 1 : 1000000 in 10 minutes.

Two grams of potassium iodide and 1 gram of mercuric iodide were dissolved in 100^{cc} of distilled water, making a 1 per cent. solution of the disinfectant in a 2 per cent. solution of potassium iodide.

This solution, diluted with sterile distilled water so as to make .1 per cent., killed the bacterium of hog-cholera taken from liquid cultures in less than 5 minutes; .01 per cent. (1 : 10000), .002 per cent. (2 : 100000), .001 per cent. (1 : 100000), and .0005 per cent. (5 : 1000000) destroyed the germ within 2 minutes.

When the solution was diluted so as to make .0002 per cent. (2 : 1000000) and .0001

per cent. (1 : 1000000) it was found that with both solutions tubes inoculated with the bacterium after a exposure of 2 and 5 minutes were opalescent, the bacterium introduced having multiplied, while the remaining tubes (10 to 30 minutes) were sterile. These two solutions, therefore, were still powerful enough to kill the germ in 10 minutes. The dilution had been carried so far as to make them practically equivalent in disinfectant power.

Sulphate of copper.—This disinfectant, which seems to be more effective than most other metallic salts, was tried in solutions containing 2 per cent., $\frac{1}{2}$ per cent., $\frac{1}{10}$ per cent. Both the 2 per cent. and $\frac{1}{2}$ per cent. solutions destroyed the germ within 5 minutes. Tubes inoculated with the bacterium after an exposure to the $\frac{1}{10}$ per cent. solution for 5, 10, and 15 minutes became turbid; those inoculated after an exposure of 20, 25, and 30 minutes remained clear.

The disinfectant power for short periods of time may be said to lie between $\frac{1}{2}$ and $\frac{1}{10}$ per cent. In this, as in other tests, one or two drops of the culture were added to 5^{cc} of the disinfectant. A slight flocculent precipitate formed each time.

Of *hydrochloric acid* a .2 per cent. solution of the acid, made by adding 4.2^{cc} of chemically pure acid (containing about 40 per cent. HCl) to 95.8^{cc} of water, destroyed the germ in less than 5 minutes.

Chloride of zinc.—A 10 per cent. solution of this salt failed to destroy the vitality of the bacterium in 10 minutes; 20^{cc} of Squibbs' chloride of zinc, containing 50 per cent. of the salt, were added to 80^{cc} of sterile distilled water to make a 10 per cent. solution. A drop from a culture five days old was mixed with 5^{cc} of this solution, from which mixture tubes were inoculated at the end of 5, 10, 15, 25, and 30 minutes. The two first tubes became clouded.

Sulphuric acid.—A .05 per cent. solution (1: 2000) was fatal to the bacterium of hog-cholera in less than 10 minutes.

Without going into detail, it is sufficient to say that the results were reached as indicated above. Tubes containing sterile beef broth were inoculated at the end of 5, 10, 15, 20, 25, and 30 minutes with bacteria exposed to $\frac{1}{2}$ per cent. and $\frac{1}{4}$ per cent. No development. Those inoculated with $\frac{1}{40}$ per cent. became clouded, each being a pure culture of the bacterium inoculated. When $\frac{1}{20}$ per cent. was tried, only the 5-minute tube became clouded. The solution (by weight) was made from sulphuric acid containing 96 per cent. of the acid (specific gravity 1.838).

It must be remembered that the foregoing tests were made upon bacteria in an active vegetative state. It is probable that in the dried condition it would have taken solutions of the same strength somewhat longer time to destroy their vitality. To briefly summarize the results, placing the least effective substance first, we obtain the following table:

Chloride of zinc in a 10 per cent. solution destroyed the bacterium in liquid cultures in 10 to 15 minutes.

Carbolic acid, 1 to $1\frac{1}{4}$ per cent. (1 : 100), in 5 minutes.

Iodine water in 15 minutes.

Hydrochloric acid, $\frac{1}{5}$ per cent. (1 : 500), in less than 5 minutes. (Only a .2 per cent. solution of this acid tried.)

Sulphate of copper, $\frac{1}{10}$ per cent. (1 : 1000), in 15 to 20 minutes.

Sulphuric acid, $\frac{1}{20}$ per cent. (1 : 2000), in less than 10 minutes.

Permanganate of potash, $\frac{1}{50}$ per cent. (1 : 5000), in 15 minutes.

Mercuric chloride, $\frac{1}{750}$ per cent. (1 : 75000), less than 5 minutes.

Mercuric iodide in $\frac{1}{10000}$ per cent. (1 : 1000000), in 10 minutes.

The above table would no doubt be somewhat changed by mixing virus imbedded in large quantities of organic matter with the disinfectant solutions. It gives, however, a good working basis for experiments on a large scale, and it throws out at once the use of chloride of zinc and perhaps carbolic acid.

In order to determine how much stronger solutions than those above given would be required to destroy the dried bacteria, the following experiment was carried out:

Spleen pulp containing large numbers of bacteria was rubbed on sterile cover-glasses so as to make a thin film, and allowed to dry for 2 days under a plugged funnel. A solution of mercuric chloride, 1 : 50000, was poured upon the cover-glasses, and one was removed after $1\frac{1}{2}$, 2, 3, 5, 7, 10, 15, 17, and 20 minutes, washed in about 100^{cc} of sterile water, and dropped into tubes containing beef infusion.

After remaining in the incubator for a day it was found that the virus exposed to the disinfectant for 1½, 2, 7, 10 and 20 minutes had been destroyed, the tubes remaining permanently clear. The others contained pure cultures of the hog-cholera bacterium.

The bacterium may be thus killed by solutions of mercuric chloride, which do not destroy spores. Koch found that anthrax spores may remain in solutions of 1: 50000 for over 60 minutes without losing their capacity for germinating. That all of the germs were not destroyed in the above experiment does not weaken the conclusion. They were undoubtedly incrusted with blood and cellular elements, so that the disinfectant could not exert its full power directly upon them. Koch, on the other hand, used spores from cultures only. The experiment demonstrates the absence of any resistant spore state in the tissues of the animal, but points out the necessity of considerably increasing the strength of disinfectant solutions in endeavoring to destroy the bacteria in nature, inasmuch as we have to deal with other things besides the germs themselves, which neutralize much of the disinfecting power.

Is there any resistant spore state in the life-history of the bacterium of hog-cholera?

Stained in dilute solutions of aniline colors the bacterium from the tissues of animals which have succumbed to the disease stains in such a way as to leave the impression that it contains an endospore. A narrow band of stained substance bounds an oval pale body, which is but slightly tinged. It appears that a rather resistant envelope prevents the coloring matter from passing readily and quickly into the interior of the bacterium.

If a drop from a recent liquid culture be suspended from the lower surface of a cover-glass and examined in a glass cell with a homogeneous immersion objective and small diaphragm, the following appearances are worthy of record: The bacteria in the center of the drop of culture fluid are in very active motion and quite small. If the periphery of the drop be examined there will be found a dense layer of bacteria caught there by the slow desiccation and consequent contraction of the drop. These, some of which are still moving slowly, are larger than the forms in the center of the drop. As the drying proceeds and the film of water becomes thin the bacteria appear to be made up of a distinct dark border surrounding an almost transparent body. In most forms there is a slightly thicker border at the ends than at the sides of the short rod-like bodies. When stained slightly this border takes the stain well, while the body of the rod remains pale. The fact that the structural and color pictures correspond is strong evidence that the microbe possesses a rather dense membrane, which in optical section is seen as a narrow dark border.

The form and size of the bacteria under consideration depend upon the culture medium and upon the age of the culture. The appearance which they present in the animal tissues is very closely simulated in liquid media, more especially beef infusions with peptone. When grown on gelatine or potato the appearance just described cannot as a rule be made out, as the bacteria are apt to be smaller.

The foregoing facts incline us to believe that we have no true spore state to deal with in this microbe, but perhaps a membrane, which is

more or less resistant, according to circumstances, and which is more resistant in the animal tissues than in cultures.

Microscopical characters, however, are now and then misleading, unless we interpret them by physiological experiments. Judging from what has hitherto been considered properties of bacterial spores, the microbe of hog-cholera cannot lay any claim to the production of true endogenous spores. Their absence is determined by results of experiments recorded in the preceding pages: 1. The thermal death-point of the bacterium at 58° C. An exposure to this temperature for 15 to 20 minutes destroys not only the vitality of cultures of all ages, but also the dried germ in the tissues of the infected animal. A momentary exposure to boiling water is equally efficacious. 2. The bacteria are destroyed by disinfectants in solutions which are incapable of destroying spores. 3. They are killed by simple drying far more quickly than are spores; at the same time their resistance to drying is much greater than might be expected under the circumstances. In the experiments recorded some dried bacteria in spleen pulp were killed in less than a month; others resisted forty-nine days. We may put the limit, which is very much less for dried cultures, between one and two months. It is this continued vitality in the dried state that suggests the existence of a membrane which is more resistant than that possessed by the great majority of bacteria in their vegetative state. This difference between bacteria in the vegetative an the spore state is illustrated by the anthrax bacillus. In cultures the bacilli are killed by drying in five or six days; the spores, under the same condition, retain their virulence for years.

All the facts brought out by the study of this bacterium lead to the conclusion that a distinct spore state, so called, does not appear either within the animal body or in nature. *

Observations on the pathogenic properties of the bacterium of hog-cholera.

In addition to the foregoing experiments on the general biological characters of the bacterium of hog-cholera, a few additional observations were made upon its pathogenic activity, with a view to determine more precisely the mode of infection.

Growth in vacuo.—It seemed desirable to learn the extent to which the bacterium was capable of multiplying with a minimum supply of oxygen. The following simple experiment was tried:

An elongated glass bulb of about 15^{cc} capacity, terminating in a narrow tube about 10^{cm} long, and containing about 5^{cc} of beef-infusion peptone, was inoculated from a pure culture. The air was then exhausted by an air-pump for fifteen minutes, while the bulb was kept immersed in a water bath at a temperature of 38° C. It was finally sealed in the flame and placed in the incubator. The results of three separate experiments were practically the same. In the bulbs the culture liquid was turbid on the following day. This turbidity increased but slightly, and within three or four days growth had evidently ceased. Four other microbes, two of which were found in the exudates of swine-plague *bacillus luteus* described in the Second Annual Report of the Bureau, a micrococcus, *bacillus subtilis*, and a microbe producing septicæmia in rabbits, were treated in the same way. None of the tubes became turbid. When, after three or four days, the bulbs were opened and filtered and air allowed to enter, the liquids became turbid within twenty-four hours, the characteristic pigment of the *bacillus luteus* appearing a few days after.

*There is no reason why the bacterium in the body of animals may not be in an arthro-sporous state, according to the classification of de Bary. The name is of little account as long as we define the properties belonging to a given state.

The bacterium of hog-cholera has therefore the power of multiplying in what is practically a vacuum, but this power is limited. The other microbes failed to show any signs of growth whatever. They were purely aerobic. The bacterium of hog-cholera may therefore be regarded as holding a place midway between those microbes which seem to thrive better without air—anaerobic—and those that fail to grow without it.

That no spores were found in these bulbs may be inferred from the following experiment: One of the tubes kept sealed for a month was opened and a number of culture tubes inoculated therefrom. They were then exposed to a temperature of 58° C. for 15, 20, 25, and 30 minutes. All remained sterile. One, inoculated without being subsequently heated, was turbid with the specific bacterium next day, indicating that it was still alive in the bulb when the latter was opened.

MODES OF INFECTION.

(*a*) *By way of the digestive tract.*—In at least 90 per cent. of swine a very severe form of hog-cholera may be induced by feeding to them the viscera of animals which have died of the disease. The lesions produced are exceedingly severe. The mucous membrane of the large intestine is extensively ulcerated or completely necrosed. In animals which have contracted the disease in the ordinary way in infected pens the ulceration of the large intestine, at times very severe, usually stops abruptly at the ileo-cæcal valve. When this is slit up, the mucosa belonging to the small intestine up to the free border of the valve is in the great majority of cases normal, while the mucosa of that surface of the valve facing the cæcum may be extensively ulcerated. In many animals fed with infectious matter the ulceration involves the entire ileum. This is well illustrated by the following cases:

January 8, 1886.—Pig No. 165 was fed with the viscera of two pigs which had died of hog-cholera. It was found dead January 26, after manifesting no marked symptoms of disease except a tendency to lie quietly in its pen. On examination the subcutaneous fat was found diffusely reddened. There was a slight peritonitis, indicated by a considerable quantity of straw-colored effusion and some fibrinous stringy deposits. There were also a few local excrescences on the small intestine, due to the irritation of *echinorhynchi*. Spleen somewhat enlarged; on its surface a few bright red punctiform elevations. Right heart distended with a clot. Local hepatizations in lungs, probably caused by lung worms, which were very numerous. Stomach but slightly reddened. A number of ulcers in the duodenum, the mucosa of which was reddened. The mucosa of the ileum for 1¼ feet from valve was completely necrosed, the walls thickened, and the serosa of this portion dotted with ecchymoses. Beyond this portion, near the jejunum, there were scattered ulcerations on a deeply congested membrane for 6 or 7 feet. The entire length of the large intestine was covered with dirty yellowish ulcerations varying in diameter from a pin's head to nearly an inch. The mucosa itself was very deeply congested in the cæcum and colon only and the walls much thickened. Ascarides and *echinorhynchi* numerous in small intestines. The liver attached to diaphragm in several places by whitish exudate.

A tube of meat infusion with peptone inoculated from the spleen of this animal was found to be a pure culture of the motile bacterium of hog-cholera. Line cultures on gelatine plates confirmed the microscopic examination. A tube of nutritive gelatine inoculated from the spleen at the same time contained in each needle track, several days later, from 10 to 15 colonies of the same bacterium. Two cover-glass preparations revealed no bacteria. This fact, combined with the small number of colonies in the tube culture, gave evidence of the small number of germs in the spleen tissue. Inoculations on mice and guinea-pigs gave substantially the same results as those obtained last year.

No. 159 was fed with the viscera of No. 165 on January 28. February 5, its eyes were sore and nearly closed; it was quite weak. It died on the following day,

only eight days after infection. The skin on abdomen was reddened in patches; the subcutaneous tissue diffusely. The superficial inguinals, as well as the glands in the abdomen, were deeply congested, the cortex more especially. Those of the thorax were nearly pale. The spleen was dotted with a few punctiform elevations. Beneath the epicardium and endocardium of both auricles and the endocardium of the left ventricle were extensive patches of extravasated blood. Kidneys enlarged and congested throughout. The lesions of the ileum, cæcum, and colon in this animal were quite as extensive as those of the case just described; there were no ulcers in the rectum, however. Those of the colon had black centers, pointing to a recent origin from blood extravasations on the surface of the mucous membrane.

In the spleen of this case the characteristic bacteria of hog-cholera were exceedingly numerous, as determined by cover-glass preparations. Two liquid cultures proved pure when tested on gelatine plates. In the needle tracks of a tube culture in gelatine innumerable colonies appeared in a few days. Inoculations from subsequent cultures proved equally positive.

Pig No. 156 was fed with the viscera of No. 159 February 18, and, after manifesting the usual symptoms of hog-cholera, died February 25, seven days after feeding. Among the marked lesions produced by the disease was a complete necrosis of the upper two-thirds of the colon, with scattered ulcers along the lower third. About an eighth of a foot of the lower portion of the small intestine, beginning at the valve, was necrosed, without manifesting distinct ulceration, for which the period of disease was evidently too brief. In the spleen there were numerous small grayish spots, probably centers of necrosis, as they showed no longer cell structure when crushed on a slide and stained. The fundus of the stomach was also deeply congested.

The spleen, to which organ the microscopic examination was limited, contained the characteristic oval bacteria, as shown by cover-glass preparations. Three liquid cultures made from the same organ were found to be pure cultures of the same microbe when tested by line cultures. A tube culture in gelatine developed in each needle track numerous non-liquefying colonies.

In these animals the mode of introduction of the virus determined the seat of the severest lesions. It is probable that the food passes quite rapidly through the small intestine; that in the stomach the action of the bacteria is more or less limited, because they have not sufficient time to multiply, and probably because hindered by the acid condition of the organ, though they will multiply with considerable vigor in slightly acid solutions. The prolonged stay of the food in the large intestine permits multiplication, and thereby causes the first and severest lesions to appear here. When these have become very extensive, so as to paralyze the action of the large intestine, the ileum becomes involved in a similar manner, possibly by a partial stoppage of the infectious matter in this portion of the intestine. This view is supported by the evidence of the above and other *post mortem* examinations in which the disease was produced by feeding.

This mode of infection by feeding viscera was used to keep up the disease at the experimental station, as simple infection in pens could not always be relied upon in furnishing cases for investigation. These few cases might therefore be supplemented by many others to show the ease with which infection may take place in this way.

In general two types of disease appear. In one the lesions are limited quite exclusively to the alimentary tract, involving the stomach, the large intestine, and often the ileum, less frequently the jejunum. There may be complete necrosis of the mucosa in the colon and ileum, with intense reddening of the fundus of the stomach. The internal organs are but slightly affected. There are few or no hemorrhages, and the bacterium is very scarce in the spleen and other organs, so that its presence is only determinable by culture.

In the other type the extensive local lesions are replaced by hemorrhagic lesions of the internal organs, involving the spleen, kidneys, lymphatic glands, lungs, and serous membranes generally. Besides these, the mucous membrane of the stomach and intestines may be

congested, and extensive hemorrhages into the submucous tissue, often into the lumen of the digestive tube, take place. These lesions have been described somewhat in detail in the last report. The spleen and blood are found to contain a large number of the hog-cholera bacteria.

Both types of the disease produced by feeding lead to a speedy termination by death in from six days to two weeks. The difference above given may perhaps be referred to a difference in the virulence of the bacteria. In the type first described the bacteria may be less adapted to a parasitic life. Their poisonous effects are exerted locally in destroying the mucous membrane. In the second type the bacteria are capable of entering the blood, to be distributed to all the organs where the hemorrhagic lesions are caused by their growth.

(*b*) *Feeding pure cultures of the bacterium of hog-cholera.*—In the preceding report (p. 207) two very severe cases of hog-cholera are reported as having been produced by the feeding of pure liquid cultures. These positive results are not always obtained, as some of the following experiments indicate:

Pigs Nos. 155 and 156 were fed February 8, 1886, with 200^{cc} of a beef-infusion peptone culture derived from a mouse which had succumbed to inoculation. The animals remained well. Pig No. 155 was fed February 1 with 100^{cc} of liquid cultures of the bacterium of hog-cholera without manifesting any symptoms of disease

The rapidly fatal effect from the ingestion of the viscera of swine containing the specific bacterium may be harmonized with the negative results above recorded when we consider the different condition of the bacterium in the liquid cultures and in the infectious viscera. In the latter case the bacteria are enveloped by connective and cellular tissue, which protect them from the destructive effect of gastric digestion, so that they are carried into the intestine where the pathological lesions are first manifested. In culture fluids the bacteria are in the most vulnerable state, and are easily accessible to the action of the gastric juice, which very probably does not permit any to pass alive into the duodenum.

That the condition of the stomach is a very important factor in the production of the disease when the virus has entered it seems a very reasonable assumption. If the virus reaches the empty stomach coated with an alkaline mucus it is more likely to multiply and reach the duodenum than when the stomach is filled with food which is being actively digested. In order to test this assumption the following experiment was tried:

December 13.—Three pigs were fed each with 300^{cc} of beef infusion in which the bacterium of hog-cholera had been multiplying for three days at a temperature of 90° to 95° F. The beef infusion had been neutralized, and sterilized in two flasks, and the cultures, when examined before the experiments, were found to contain the motile bacterium only.

The pigs were prepared for the feeding as follows: No. 348 received no food for over twenty-four hours. A 2 per cent. solution of sodium carbonate in beef infusion was then given to increase the alkalinity of the stomach. Of this about 1 liter was consumed. It was then fed with 300^{cc} of culture liquid mixed with beef-broth to make 1 liter. No. 350 was starved in the same way, but received no alkali before consuming the culture. No. 342 was not deprived of food before eating the culture.

The result confirmed our anticipations. No. 348 showed signs of disease in two days. On the third it was unable to rise, and died on the same day. The *post mortem* examination showed a considerable congestion of the mucous membrane of the duodenum and jejunum, as well as of the large intestine. The fundus of stomach affected in the same way. The liver was gorged with blood, as well as the portal system. There were no marked lesions of the other viscera. That the hog-cholera

bacterium had also entered the blood was shown by two pure cultures in beef infusion obtained from the spleen. A gelatine culture from the liver contained about 6 or 7 colonies.

No. 350 was a more typical case, and demonstrated the severe local effects of the bacterium much better, since the animal lived longer. It ate fairly well until the fourth day, when its appetite gave way and diarrhea set in. From this time it grew weak and thin, being scarcely able to walk. It died on the tenth day after feeding. The lesions of the alimentary tract were exceedingly grave. Beginning with the stomach, the mucous membrane was dotted with closely set elevated masses as large as split peas, and larger patches of a whitish viscid substance, made up entirely of cellular elements (diphtheritic?). When removed, a raw depressed surface was exposed. The membrane itself was pale. Besides a general injection of the iliem, Peyer's patches were more deeply congested, and the uppermost covered with a thin yellowish film, not removable, and most likely dead epithelium. In the cæcum and colon the mucosa was superficially necrosed, and converted into a continuous layer of a dirty whitish mass about 1^{mm} thick. The walls of the intestine were greatly thickened and very friable.

Microscopic sections showed an extensive cellular infiltration of the submucous connective tissue which had separated the masses of fat cells, concealed the connective tissue fibers, and caused a great thickening of the entire layer. The mucosa itself was greatly altered. The surface was necrossed and converted into an amorphous mass. In some places the necrosis involved the entire depth of the crypts of Lieberkühn, a series of striæ indicating their former existence. Those whose epithelium still remained were plugged with a cylindrical mass, filled with broken-down nuclei. The bacteria had exerted their poisonous effects from the surface of the mucosa towards the depths, destroying the surface epithelium and glandular structures and involving secondarily the submucous layer. Near the rectum this continuous mass of dead tissue was replaced by isolated ulcers embedded in an intensely reddened mucosa. Plate II, taken from another case, illustrates well the superficial death of the mucosa. The ileo-cæcal valve was much swollen, but the necrosis did not extend into the ileum, although there were a few ulcers near the valve, and the epithelium had a pale, lusterless aspect, as if dead. The liver was filled with blood, which readily clotted as it flowed from the cut surface. Spleen congested and but slightly enlarged. Lungs hypostatic. The lymphatic glands in general not much affected. Two liquid cultures from the blood were turbid next day, and contained the hog-cholera bacterium only. In a gelatine tube culture from the liver about a dozen colonies developed in each needle track.

No. 342, which was fed with the same quantity of culture liquid but was not deprived of food previously, was somewhat ill on the following day. It recovered, however, and continued apparently well for several weeks. It began thereupon to grow thin and weak. On January 26 it was no longer able to rise, and was therefore killed for examination, in order to conclude the experiment. On opening the abdominal cavity it was at once perceived that the animal had been suffering from a very intense disease of the large intestine, a portion of which was firmly attached to the bladder. When dissected out and slit open, the mucous membrane of the cæcum and colon was found replaced by a brownish friable layer of necrosed tissue. The wall of the intestine was infiltrated to such an extent that it was nearly ¼ inch thick, and so degenerated that the forceps easily tore through it. The thickness of the walls prevented the intestine from collapsing after it was opened. Its only contents was a brownish liquid mass. The glands of the meso-colon were very large, some like horse-chestnuts. On section the entire tissue was very pale, almost white. The spleen was somewhat enlarged; the malpighian corpuscles unusually large and prominent on section. Lungs and heart normal; kidneys deeply reddened throughout on section.

This case is very interesting in completing the information gained by this feeding experiment. No. 348, which had been fed with sodium carbonate besides being deprived of food, died three days after the ingestion of the culture. No. 350, which was simply starved, died ten days thereafter, while No. 342, which ate the culture without being previously starved, was dying on the thirty-fourth day.

These results show how easily infection may occur by way of the digestive system, provided the destructive action of gastric digestion be prevented, as was done by starving and by the use of an alkaline carbonate.

They also indicate how purely local this destructive action may be. Gelatine cultures from these animals showed that the internal organs contained but very few bacteria. So few were they in fact that the

microscope alone could not have demonstrated their presence, as they could not be found on cover-glass preparations.

Other successful experiments by feeding pure cultures will be given in connection with a description of the bacterium from different parts of the country.

(c) *Subcutaneous inoculation with pure cultures.*—The least successful method of producing the disease is the subcutaneous inoculation of pure cultures. In the report for 1885 at least three out of four inoculations produced a rapidly fatal form of the disease. In the numerous experiments to be described later, in which pigs were inoculated with cultures to determine whether any future protection was thereby granted, only five died from the inoculation. In these experiments two subcutaneous injections were practiced, a small quantity being followed by a larger quantity of culture liquid. The deaths occurred from the first injection when this was made comparatively large; the second dose, which was usually quite large, was borne without any ill effects.

These successful inoculations, reported *in extenso* in another section, are briefly as follows: No. 239, inoculated April 27 with $\frac{1}{2}$cc culture liquid, died May 2, only six days after inoculation. Hemorrhagic condition of vital organs. Though seven others were treated in the same way none took sick. It may be that in this individual the needle entered a superficial vein, and in this way introduced the virus directly into the blood.

Nos. 204 and 212, inoculated April 12 with $1\frac{1}{2}$cc culture liquid, died eleven and seven days after inoculation, respectively. In the former the mucosa of large intestine was entirely necrosed. In the latter ulceration was just beginning.

Nos. 208 and 209, inoculated at the same time with 1cc of the same culture, died fifteen and six days after inoculation respectively. Numerous extensive ulcers in the large intestine of 208. In 209 general congestion and extravasation along digestive tract and in internal organs. With each pair two others had been inoculated without any untoward results.

The local swelling at the point of inoculation is usually proportionate to the quantity of culture fluid injected. The following cases show how large quantities may be borne without inducing the disease:

Nos. 116 and 154 were inoculated February 8 by the subcutaneous injection of $3\frac{1}{2}$cc of the second culture from the spleen of No. 165 in beef-infusion peptone, one-half being injected into each thigh. A very large swelling appeared at the seat of inoculation in No. 154, causing considerable lameness. March 4 this animal was killed, although evidently not diseased. The inoculation tumor was over 1 inch long and $\frac{1}{2}$ inch thick; firm, yellowish-white, developed in the loose connective, and only loosely attached to skin and subjacent mucular tissue. There was considerable serum in the abdominal cavity, and the spleen was somewhat enlarged. In the fatty tissue lining the dorsal wall of the abdominal cavity numerous worms were found (*Sclerostoma pinguicola*), occupying tunneled spaces in the fibro-adipose mass. No indications of hog-cholera. No. 116 was not affected.

No. 181 was inoculated February 13 with 7cc of the second liquid culture from the spleen of pig No. 159. Within a few days the animal became lame, but this passed away. At the seat of inoculation large tumors had developed, no doubt causing the stiffness of the hind limbs. This animal was killed March 4. At each point of inoculation were found firm fibrous masses, from 2 to 3 square inches in extent and nearly an inch thick. No suppuration. There were no lesions pointing directly to hog-cholera. There was, however, a considerable quantity of pale serum in the abdominal cavity. Spleen enlarged; cortex of kidneys dull, thickened; lymphatic glands of large intestine somewhat prominent, but pale.

These animals may have suffered from the absorption of ptomaines from the place of inoculation, but dissemination of the bacteria through the internal organs evidently did not take place to any extent.

The failure to produce the disease in even a small proportion of animals by the injection of liquid cultures raised the question whether the cultivation in itself did not attenuate the bacteria. Consequently

two experiments were made by inoculating with blood directly. Numerous gelatine cultures of heart's blood had demonstrated the very small number of bacteria compared with the number present in the spleen.

September 10.—A pig dying with the disease was killed, the heart carefully exposed, and the blood drawn with a disinfected hypodermic syringe. Nos. 329 and 333 received subcutaneously 5^{cc} each, one half in each thigh. No. 329 in a few days lost its appetite, became weak and stupid. Found dead October 5. Slight local swelling at the points of inoculation; superficial inguinals greatly enlarged; hypostatic congestion of lungs; complete necrosis of mucous membrane in cæcum; large scattered ulcers in colon, showing as whitish patches on serous surface and encircled by a crown of enlarged blood vessels; bacteria in spleen.

No. 333, slightly ill for a time; fully recovered. Died December 2 with no other lesions than engorgement of liver. No signs of former ulceration.

A second experiment was made in the same way:

October 13.—Nos. 324 and 325 inoculated as in the preceding experiment, 10^{cc} of blood being used for each animal. No. 324 was found dead November 1, after being off feed for a time. Deeply reddened skin over caudal half of abdomen; extremely large and serously infiltrated superficial lymphatics; on section, hemorrhagic points. At point of inoculation the connective tissue is infiltrated; 50^{cc} to 75^{cc} clear amber serum in abdominal cavity; papillæ of kidneys deeply reddened; slight congestion, but no ulceration in large intestine; lymphatics in general moderately tumefied and congested.

No. 325 found dead October 29. Reddening of skin as in 324; extravasation in connective tissue; spleen greatly enlarged, purplish; lymphatics of thorax and abdomen purplish, enlarged; petechiæ on section of kidney and in pelvis, also over entire surface of epicardium; lung tissue mottled both on surface and on section with purple spots, due to blood extravasation into alveoli, so that it scarcely floats. Mucous and serous surface of small intestine dotted with petechiæ; small hemorrhages on the surface of the mucous membrane and into the submucous tissue of the cæcum and upper colon. Ulceration beginning.

These results are more positive than those obtained with cultures, and on first thought we may be inclined to attribute them to a greater virulence of the germs in the injected blood. This view needs further confirmation, however. The injected blood coagulating in the connective tissue contains in it the bacteria, which are not only protected from the aggression of cellular elements, but have actually a store of nourishment upon which they may live and multiply. No such advantages are presented to bacteria suspended in liquids which are readily absorbed, leaving them to the mercy of the tissues surrounding them. The local reaction in the above animals was very insignificant compared with that produced by liquid cultures. In order to come to any conclusion, it would be desirable to add a few bacteria from cultures to fresh blood, and observe the relative virulence in the way indicated above.

Taking the foregoing results into consideration, the alimentary canal must be considered as the most vulnerable point for the entrance of the bacterium of hog-cholera. It is probably the chief, if not the only, entrance of the virus when the infection takes place among herds. The occasional occurrence of lung lesions as extensive hepatization in advanced cases of hog-cholera suggested to Klein the name of pneumo-enteritis. In the many cases carefully examined at the experimental station the lung lesion did not appear to surpass in severity those of the internal viscera and the lymphatic system. In the great majority of animals lung-worms were usually found associated with localized atelectasis. The collapsed portions had a red flesh color. Many cases of chronic hog-cholera, associated with extensive ulceration of the large intestine, had normal lungs. On the other hand, cases of a very acute hemorrhagic type, produced by feeding infec-

tious material or by subcutaneous inoculation, presented throughout the lung tissue small hemorrhagic foci involving several contiguous lobules. On section they were of a dark-red color, and indicated extravasation into the alveoli, which were filled up with coagulated blood. These foci are very likely caused by plugs of bacteria growing in the capillaries, producing necrosis of their walls and consequent extravasation. Taking into consideration the condition of the remaining viscera in such cases, it is highly probable that the foci are not primary, but secondary in character. They are not growths of the bacteria introduced by the inspired air, but carried there by the circulation, the original place of entrance being the alimentary tract. These centers of growth may gradually spread and involve the entire lung substance, giving rise to that extensive hepatization occasionally found. That infection may arise through the air in some cases, especially in summer, when the bacteria are dried and carried away as dust, is not necessarily excluded. The greater activity of the virus in the warm seasons cannot be entirely due to its dissemination in this manner, since drying destroys the bacteria of this disease in from one to two months, and it may reduce their pathogenic power in a much briefer time. The greater diffusion and mortality must be attributed to more favorable opportunities for the bacteria to multiply outside the animal body in streams and in the soil on animal and vegetable substances. In this connection it might be well to record the following experiment:

Two pigs placed in an air-tight box were subjected to the spray of an atomizer containing 10^{cc} of a liquid culture of the hog-cholera bacterium diluted with 40^{cc} of distilled water. The spray was directed upon the faces of the animals, which they could not avoid, owing to the small size of the box. They were removed at the end of thirty minutes and placed in a disinfected pen. After a few days they seemed somewhat dull, but both recovered. Several months after one of them died of hog-cholera on being fed with infectious material. It is highly probable that the bacteria were carried into the lungs at the time.

In view of the fact that another bacterium has been recently found associated with severe lung lesions, and is probably the cause, it becomes necessary to re-examine diseases of the lungs, whether associated with true hog-cholera or occurring independently. The subject is fully discussed further on.

Cycles of virulence.—The variation in the severity and extent of epidemics of infectious diseases has been a subject for observation and comment by all who have studied them more carefully. It is characteristic of infectious diseases attacking man as well as those to which animals are subject.

The change in virulence is indicated both by the number of animals affected in a given time and by the suddenness with which they are struck down after infection. The record of cases of hog-cholera kept at the experimental station for more than a year is very instructive, in showing clearly how the virus of a specific disease may become very much attenuated, then suddenly regain its virulence, sweep away a large number of animals very rapidly, then again lose its virulence until it has scarcely any effect upon the animal system. This change in virulence is indicated in various ways. When attenuated the virus produces a chronic disease, characterized by local ulcerations of the mucous membrane in the large intestine. The affected animal lives for four or more weeks. This is the way in which the disease manifests itself most commonly. When the virulence is great the disease is rapid, the lesions hemorrhagic in charac-

ter, involving nearly all the vital organs. These are found to contain the specific bacterium in large quantities. Subcutaneous inoculations of cultures derived from such cases will in general produce a disease as severe and as rapidly fatal. When the pigs are fed with the viscera from these same cases even more severe local and general lesions are the result. From such a height of virulence there is a gradual descent. Animals which have become infected in the natural way are attacked by a milder and more protracted disease. Inoculations of cultures become less successful or fail altogether. Even when fed with the viscera of animals which have died of the disease, pigs will after a time become affected with a slow chronic malady. In these milder forms of the disease comparatively few bacteria penetrate into the vital organs to multiply there. Cover-glass preparations of spleen pulp do not show a single microbe in many fields, while the same preparation from hemorrhagic cases may show from 50 to 100 in every field of a $\frac{1}{18}$ homogeneous objective. Nor does the quantity of virus introduced materially change the result. When the disease is at its highest point of virulence cases of natural infection are frequently as severe as those fed with large quantities of virus. On the other hand, when animals are fed with cultures of more or less attenuated virus, the local destruction of tissue in the intestines may be very grave and cause speedy death, but the internal organs remain more or less intact.

This change in virulence has not been observed in experiments upon mice, rabbits, and guinea-pigs. The same peculiar lesions have appeared throughout a period of fourteen months. The duration of the disease may vary, but this depends upon the quantity of virus introduced into the system. The lesions in the protracted cases due to the inoculation of very small quantities are if anything more pronounced.

What agencies are at work in bringing about this variation in virulence is a problem still to be solved. There is no clew to an explanation, and we simply record the facts as observed. There seems to be a sufficient reason for regarding the increase of virulence as due to climatic and meteorological conditions affecting the bacterium outside of the body, for our own observations show that the successive passage of the virus through the body of pigs by feeding diminishes its virulence and may finally destroy it.

The relation of the virulent and attenuated bacteria to the animal organism is expressed by the statement that the former are capable of living and multiplying in the blood vascular system of the infected pig, while the latter are unable to do so. Their destructive action is limited to the intestinal tract. There may be two properties by whose change a virulent bacterium becomes attenuated, and *vice versa*—the capacity of living with a limited supply of oxygen, and the power of forming a poison or ptomaine which is more or less destructive to cellular life. Either or both of these properties, when augmented or diminished, may bring about the differences which are observed between malignant and mild types of the disease.

EXPERIMENTS UPON OTHER ANIMALS WITH THE HOG-CHOLERA BACTERIUM.

Mice infected by feeding.—It was desirable to determine how far the bacterium of hog-cholera was infectious to other animals besides pigs when introduced with the food into the alimentary canal. Mice, being susceptible to inoculation, might contract the disease about the pens, and being eaten by pigs would quite naturally become a source of infection. To determine this point bread and spleen were thor-

oughly mixed by mincing them together. Two mice ate of this mixture, and one was found stupid, scarcely able to move about on the following day. The same material was fed a second time. Both were ill on the next day. They crouched, somewhat sprawling, with head down, staring coat, and eyes partly closed. On taking them out of the jar they were unable to move; when pushed forward they moved a few steps. These symptoms passed away on the third day. Five days after the first feeding one was found dead. The other was fed again six days after the first feeding. It was found dead two days after the last feeding. The first feeding had therefore taken effect. The liver showed the formation of islets of coagulation necrosis and was crowded with the bacteria of hog-cholera. The very peculiar condition of these animals on the second and third day after feeding can only be explained by assuming the active multiplication of the bacteria in the intestinal canal and the formation of a ptomaine, which, on being absorbed, produced a systemic effect. The invasion of the internal organs themselves from the alimentary canal manifested itself later by the death of the animals and the presence of the ingested bacteria in the spleen and liver.

Two additional mice were fed in the same way. One escaped. The other failed to show any symptoms referable to the ptomaine, though fed four times. It remained well for over two weeks, when it began to breath laboriously and became very weak. It was killed with chloroform twenty-five days after the first feeding. The spleen was found enormously enlarged, but there were no bacteria on one cover-glass preparation. One lobe of each lung was solid, whitish, crumbling, evidently the result of coagulation necrosis. This mass was crowded with what appeared under the microscope as bacteria of hog-cholera. No cultures were made. This animal, therefore, judging from the enlarged spleen and the necrosed lungs, was also the victim of hog-cholera. Another mouse fed in the same way was dying four days after, but found drowned in the drinking cup next morning, thus preventing microscopic examination of the organs.

To determine whether these animals could be infected with pure cultures, a mouse was fed with bread which had been saturated with about $\frac{3}{4}^{cc}$ of a liquid culture and dried for an hour in the incubator. The feeding was repeated on four successive days. Seven days after the first feeding the animal was plainly ill, and it died on the following day. This would indicate that the first or second feeding had taken effect. The spleen was enlarged, the vessels of the mesentery very prominent and filled with blood. The bacteria were very abundant in the spleen, moderately so in liver and kidney. A second mouse fed with cultures was found drowned on the eighth day.

Two mice, kept in separate jars, were fed with a mass consisting of bread and gelatine culture thoroughly mixed. The gelatine culture had been prepared by passing a glass rod dipped in a liquid culture over the surface of a layer of gelatine. The gelatine after five days was covered with a thin opaque layer, consisting of confluent colonies. Both mice ate the dose. One was found dead next day in a crouching posture; the poison had evidently killed it in a very short time. The other did not appear disturbed by the absorption of the ptomaine, but it died from general infection on the sixth day. The spleen was considerably enlarged. Both spleen and liver contained large numbers of hog-cholera bacteria.

These few experiments show the possibility of an infection of mice through the food, and of the transportation of the disease through the agency of these animals. They show incidentally the effect on the system of the absorption of the ptomaine produced by bacteria in the alimentary canal.

Feeding was also tried on pigeons by saturating the feed with the culture liquid and allowing it to dry. No marked effect was produced. The feces were unusually liquid and abnormal in appearance for some time.

Guinea-pigs very susceptible to hog-cholera.—In order to determine the effect of very small doses on guinea-pigs, two animals, Nos. 3 and 4, which had been kept for more than a month under observation, were inoculated by injecting under the skin of the inner aspect of the thigh about $\frac{1}{2000}^{cc}$ of a culture in meat infusion with 1 per cent. peptone, prepared from the spleen of a pig on the day previous. To obtain such a small dose the culture liquid was diluted with sterile salt solution, and about $\frac{1}{4}^{cc}$ of this injected. On the third day both were unusually quiet and rested together; respiration seemed more labored; the animals moved unwillingly when disturbed. No. 3 was found dead on the morning of the eighth day, and No. 4 died at noon on the same day.

On examination the skin of No. 3 was found discolored at the place of inoculation. The surface of the muscular tissue at this point was dotted with ecchymoses, interspersed with whitish areas which corresponded to altered muscular tissue. This was whitish, friable, evidently dead. Such masses could be found to a depth of 1^{cm} in the muscles of the thighs. This alteration seemed to follow along the planes of the intermuscular septa. A patch about 1^{cm} in diameter on the muscular wall of the abdomen contiguous with the place of inoculation was similarly affected. In the abdomen the vessels of the intestine were injected, spleen full of blood, mottled dark red and grayish, friable. Lungs somewhat congested. The stomach contained a small mass of food embedded in considerable viscid translucent mucus; the cæcum and large intestine were filled with a yellowish soft food mass.

The bacteria of hog-cholera were present in large numbers in the liver and spleen. There were fewer in the kidneys and lungs; very few in blood from the heart. A tube culture in gelatine from the spleen developed numberless colonies in each of three needle tracks, growing precisely like cultures from the spleen of swine. A liquid culture from the blood showed the motile bacterium on the following day, and line cultures made therefrom revealed the same growth on plates as that from swine.

Guinea-pig No. 4 presented the same local as well as general lesions. The spleen was dark in spots and very friable. Vessels of the mesentery injected. The bacteria were as abundant in the organs as in No. 3. Cultures made as described for No. 3 proved identical with the latter.

These animals are as a rule more refractory than rabbits with reference to the virus of *rouget*, rabbit-septicæma, and a new pathogenic microbe described in a subsequent section of this report.

Microscopic examination of tissues of infected animals.—In sections of tissues from cases of hog-cholera, cut after being imbedded in pure paraffine, the bacteria stain very well in aniline water methyl-violet. The sections may be treated afterward with a $\frac{1}{2}$ per cent. solution acetic acid without removing the stain. Treated in this way and examined with a $\frac{1}{12}$ or $\frac{1}{18}$ homogeneous immersion the bacteria appear in plugs or clumps, never isolated. In the spleen such colonies are seen in the spleen pulp near the trabeculæ; in the kidney the plugs are rare even in the most hemorrhagic cases. In sections of the wall of the large intestine of a recent case in which there was much extravasation, the submucous tissue was infiltrated with red blood corpuscles, which had forced their way between the bundles of areolar tissue and among the fat cells. Occasionally masses of corpuscles were seen beneath the serosa. In a number of sections carefully examined no bacteria could be detected.

When we take into consideration the coagulation necrosis produced by this bacterium when injected beneath the skin in mice, pigeons, rabbits, and guinea-pigs, and its tendency to grow in plugs or colonies, the hemorrhagic effect is easily explained. The growth in the smaller blood vessels coming in contact with the walls destroys them and gives rise to extravasation. In the intestinal mucosa the extravasation may lead to a cutting off of the food supply and consequent necrosis and ulceration.

The liver of a mouse which had succumbed to hog-cholera, interspersed with whitish specks and patches of necrosed tissue, was examined in the same way. The section contained unstained areas corresponding to the patches of coagulation necrosis seen with the naked eye. These unstained areas are dotted with stained, shriveled nuclei and surrounded by a zone of leucocytes. The bacteria are found in small clumps both within and on the periphery of the unstained areas. They are also present in the capillaries of the surrounding tissues. In the larger vessels they are present, but scattered.

In the muscular wall of the abdomen of a guinea-pig invaded from the seat of inoculation on the thigh the bacteria had penetrated in

immense numbers through the connective tissue surrounding the individual fibers and produced extensive extravasation, thereby forcing the bundles of fibers apart.

THE BACTERIUM OF HOG-CHOLERA IN OTHER OUTBREAKS.

In an outbreak of hog-cholera at Ivy City, D. C., several miles from the Experimental Station, the same lesions were found, coupled with the presence of the previously described bacterium, as shown by the following notes:

Pig No. 261.—Brought to the station a few hours after death. Considerable reddening of the skin of the limbs and over the pubic regions. Extravasations into the subcutaneous adipose tissue; considerable deeply stained serum in abdominal cavity; spleen very much enlarged and gorged with blood. Lymphatic glands in thorax and abdomen all deeply congested. Hemorrhagic foci in lungs. Mucous membrane of cæcum and upper colon almost black, the remainder deeply congested. Numerous small ulcers scattered over the mucosa of cæcum and colon. Besides these, there were, about 6 inches from the valve, two ulcers nearly 1½ inches across, so deep as to produce an inflammatory adhesion between the serous surface of the intestinal wall and adjacent organs. The mucosa of the fundus of the stomach deeply congested; numerous small ulcers near pyloric region. The small intestine unaffected, if we except a few petechiæ. Both kidneys much swollen; glomeruli gorged with blood; also the pelvis and bladder. In the spleen the bactera of hog-cholera were very abundant, as shown by cover-glass preparations. Two liquid cultures therefrom were pure, as determined microscopically and on gelatine plates.

This case is interesting from two points of view. It demonstrates the identity of cause of two virtually independent centers of the disease. It also suggests a double infection; the first causing the few deep ulcers and probably only a very slight general infection; the second invading the entire body, producing rupture of the blood vessels by a necrosis of the vascular walls.

Another outbreak near the city of Washington presented the same features. The spleen of the animals which succumbed contained the bacteria of hog-cholera only.

The Bacterium of Hog-cholera in Nebraska Outbreaks.

Early in March of the present year (1886) Dr. W. H. Rose was sent to the West to collect material for the study of hog-cholera, in order that a comparison with the disease as it exists in the East might be made. Is the disease identical with that described in the Second Annual Report? If the cause can be proved the same, the diseases must necessarily be regarded as identical.

It was thought best to use the spleen, which has nearly always furnished pure cultures of the specific bacterium, and which, in the great majority of the cases, contains the bacteria in such numbers that they may be easily detected in cover-glass preparations. The spleen was removed from the body of pigs killed for that purpose and placed in a bottle plugged with cotton wool, which had been sterilized at 150° C. Spleen pulp was rubbed upon slides, dried, and sent with the bottles.

Ten animals were examined in all, about three from Kansas and the rest from three different places in Nebraska. From the notes sent there seemed to be little doubt that the lesions resembled those described in the preceding report very closely. As to the spleens, none of them arrived at the laboratory in good condition. Some of them were partially decomposed; others were covered with fungi and zooglœa of micrococci. Cover-glass preparations revealed a variety of forms, most of them large bacilli, some spore-bearing. In only one

case did a bacterium resembling the microbe of hog-cholera appear amongst a number of other forms. We shall return to this case later on.

Of the slide preparations the dried films were searched in vain for the presence of the bacteria, indicating plainly the external origin of the putrefactive forms. Plate cultures were made in a few cases without any promising results. Mice were inoculated with bits from a number of the spleens by introducing them beneath the skin of the back. A few mice died, probably of malignant œdema, and the rest remained well.

In only one case was the result unexpectedly successful. This came from Tecumseh, Nebr., the spleen in which the bacterium seemed present in cover-glass preparations. Plate cultures and line cultures directly from spleen pulp were equally unsatisfactory, owing to the variety of germs present.

Two mice, Nos. 69 and 70, inoculated with bits of spleen tissue, furnished a key to the problem. Both were inoculated March 23; one died March 30, the other April 1. In No. 69 there was a very large quantity of serum in the subcutaneous tissue of the skin about the abdomen and in the abdominal cavity. The liver, especially along its border, was dotted with small patches of coagulation necrosis. A cover-glass preparation of spleen and liver negative. The culture from the effusion contained several forms of bacteria, as might have been expected. A liquid culture of the blood seemed a pure culture of a *motile oval bacterium*, resembling closely the bacterium of hog-cholera. In No. 70 the lesions were more nearly identical with those observed after inoculating mice with the bacterium found in the East. The lymphatics of the knee fold and the spleen were very much enlarged; the liver contained small patches of coagulation necrosis; lungs and kidneys congested. Bacteria, not to be distinguished from those of hog-cholera, were found abundantly in spleen, liver, and heart's blood; in small number in lungs and kidney. The liquid culture was identical with that from No. 69. A tube culture in gelatine and line cultures from the liquid cultures failed to grow for reasons discovered later on.

In order to determine whether the bacterium obtained from these mice was pathogenic or not, four mice were inoculated April 6 (Nos. 75 and 76), from the culture of No. 69, 77, and 78 from the culture of mouse 70, each receiving from 5 to 10 drops of the culture liquid. April 12 all four mice were found dead. In No. 76 there were signs of commencing necrosis in the liver. There were no marked lesions observed excepting a variable enlargement of the glands in the knee fold. In the liver and spleen of every animal the oval bacteria, with pale center, were present in large numbers. As these had succumbed in less than six days, the most characteristic lesions, great enlargement of the spleen and coagulation necrosis in the liver, were absent. These changes were invariably produced with the hog-cholera bacterium first described when very minute quantities were inoculated, by which the period of disease was prolonged for nearly two weeks from the date of inoculation. April 20, Nos. 84 and 85 were inoculated with 5 drops of a culture derived from mouse No. 78. No. 84 died in two days, and No. 85 died in six after inoculation. In both the characteristic bacteria were present in spleen and liver. At the same time Nos. 82 and 83 were inoculated from the culture obtained from the blood of mouse No. 77. No. 82 died two days after, and No. 83 seven days after, inoculation. In the latter case the longer time had allowed the formation of coagulation necrosis in liver and great enlargement of the spleen.

This new microbe, identical morphologically with the bacterium of hog-cholera already described, produces a disease in mice which is practically the same as that produced by the latter microbe.

The effect of these two bacteria is the same on rabbits. May 22 a young rabbit received subcutaneously an equivalent of .001^{cc} of the eleventh culture (mouse) four days old. No symptoms of disease appeared until June 5, fourteen days after inoculation. It was then very quiet, refusing to move and breathing with some effort. On the following day it was found dead. The autopsy revealed the following lesions:

At the place of inoculation was found a yellowish-white mass resting on thg muscular tissue and covering an area about 2^{cm} in diameter. This mass, consistine

of necrosed tissue, did not crumble readily between the forceps. The superficial veins in the vicinity were dark and distended with blood. On the contiguous abdominal wall there was a patch about 2^{cm} diameter closely studded with small extravasations. These were found isolated as far as the lowest ribs on the same side. In the abdominal cavity there was a small quantity of stained serum. The intestines and bladder were lightly glued to each other and to the abdominal walls. The spleen but slightly augmented in size. The liver studded with minute isolated whitish points of coagulation necrosis. Lungs mottled with a bright red throughout. In the spleen and liver the bacteria inoculated were abundant. A culture in nutritive gelatine from the liver grew precisely like former cultures. Two cultures in beef-infusion peptone were turbid on the following day, and had a complete membrane.* Both were pure cultures of the motile bacterium inoculated.

A young rabbit inoculated May 28 with a comparatively large quantity ($\frac{1}{8}^{c}$) of the thirteenth culture (mouse) was found dead June 3. The local and general lesions were the same as those above detailed. The bacteria were present in considerable numbers in spleen and liver.

In liquid cultures from blood of heart and liver the motile bacterium only was found, forming a surface membrane. Cultures in gelatine were equally satisfactory. The lesions produced by this bacterium resembled those produced heretofore by the bacterium discovered in the East very closely. The spleen, however, was not markedly enlarged.

Effect on pigeons.—Two young pigeons were inoculated April 23, beneath the skin over the pectorals, each with $.6^{cc}$ of a culture from a mouse. They appeared unaffected until April 27, when the feathers became ruffled and the birds moved about with difficulty. They became worse, exhibiting the usual appearances of pigeons inoculated with the hog-cholera bacterium; feathers much ruffled, so as to give the birds a puffed appearance, tail feathers drooping, head drawn in and depressed. Discharges of a mucous character. One was found dead April 30, the other died in the course of the same day. In both the pectorals presented the parboiled appearance due to the local effect of the culture and previously described. In one bird the bacteria were abundant in the liver, few in the spleen; in the other there were but a few in both organs. Finally, liquid as well as tube cultures in gelatine were successful in containing the bacterium inoculated. Another pigeon inoculated at the same time, which had been fed with spleen unsuccessfully some weeks previously, did not become sick. After two weeks it was killed, and in each pectoral an elongated sequestrum was found surrounded by a membrane and evidently in process of absorption. Another pigeon previously vaccinated and inoculated with the bacterium of the East, and now inoculated with this bacterium from Nebraska, remained perfectly well. Two other pigeons were inoculated April 24, for the sake of comparison, one with $\frac{3}{4}^{cc}$ of a liquid culture of the Eastern, and the other with the Western variety. Both pigeons exhibited the characteristic symptoms above described. The former died April 30; the latter recovered. When killed later only a small sequestrum was found at the seat of inoculation. In the former, bacteria were found in spleen and liver. A tube culture in gelatine from liver and a liquid culture from blood of heart were both cultures of the Eastern germ. The bacterium failed to show any pathogenic effects when injected beneath the skin of two guinea-pigs. The same culture which was promptly fatal to a rabbit had no effect whatever on a guinea-pig inoculated at the same time.

Whether we are here confronted by a very slight attenuation or weakening of the virus with reference to guinea-pigs, due to prolonged cultivation in artificial media, with an occasional rejuvenation by its passage through a susceptible animal, or whether the difference in activity between it and the bacterium from Eastern outbreaks of the disease is in reality due to a permanent physiological difference, remains to be determined by additional experiments.

In order to determine the effect of inoculation upon pigs at the Experimental Station, bits of two spleens from Nebraska were introduced beneath the skin of each thigh and the remainder fed to the same animals on March 16. A slight swelling at the place of inoculation soon subsided. As no results followed, the same animal was fed April 28 with portions of the spleen of four or five pigs which had died of hog-cholera at the Station. It was found dead May 4. Without giving the autopsy notes in detail, it is sufficient to state that

*This bacterium differs from the one described in forming a surface membrane on liquids.

among other lesions the large intestine and ileum were more or less ulcerated.

May 12, two pigs (Nos. 234 and 237), were inoculated each with about $3\frac{1}{2}^{cc}$ of a seventh culture obtained originally from a mouse. One-half was injected beneath the skin of each thigh. There being no indications of any disease after this inoculation, No. 237 was fed July 10 with portions of viscera from cases of hog-cholera, and was found dead July 15. No. 234 was fed July 25, and died from the effects August 8. No. 219 received May 28 10^{cc} of a liquid beef-infusion peptone culture, one-half into each thigh. At both places a small tumor developed, which did not disappear. This animal seemed unaffected by the inoculation, and was fed, together with No. 237, July 10. Both died on the same day. In both animals there was considerable superficial necrosis in the cæcum and colon, and complete necrosis of the mucosa of the major portion of the ileum. In No. 219 there was an encysted mass about the size of a marble in the subcutaneous connective tissue at the place of inoculation, freely movable. On section a grayish-white cheesy mass, partially converted into a liquid in the interior, could be easily peeled out of a capsule, the inner surface of which was considerably reddened. In Nos. 237 and 219 the spleen contained the bacterium of hog-cholera, as determined by cover-glass preparations. No. 234 was not examined. The subcutaneous inoculations having proved unsuccessful thus far, a pig was fed June 4 with the viscera of a rabbit which had died from the inoculation, and the organs of which contained the bacterium in abundance. June 9 a second rabbit was fed to the same pig. July 20, one month and a half later, the animal being apparently in good condition, it was fed with the viscera of a pig which had died of hog-cholera at the station. After some days of marked debility it was found dead August 9. It presented the lesions consequent upon a general systemic invasion of the virus, greatly augmented spleen, deeply congested lymphatic system, hemorrhagic foci in lungs, and extensive necrosis of cæcum and upper colon.

The negative results of these few experiments must not incline us to reject the conclusion that the microbe under consideration was actually the cause of this outbreak of swine disease in Nebraska. When we remember how closely it resembles in its cultures, reaction and its pathogenic effect upon smaller animals the bacterium which was demonstrated to be the cause of the disease as observed for over a year at the Experimental Station, the evidence from the standpoint of to-day becomes too strong to be set aside. We must also remember that the culture was obtained early in March, and was kept for inoculation experiments without re-enforcement from any fresh cases of disease for several months, and that the disease is only exceptionably produced by subcutaneous inoculation. Our information concerning the attenuation of this virus under cultivation is very meager, although it is highly probable that any microbe adapted to a parasitic existence will suffer by artificial cultivation.

In order to determine whether the disease could be produced by feeding the bacterium from Nebraska in liquid cultures, two pigs (Nos. 383 and 384) were fed, each with about 250^{cc} of a beef-infusion culture after being starved for over twenty-four hours. No. 383 received previous to the ingestion of the culture liquid about 1 liter of beef broth to which 1 per cent. sodium carbonate had been added. The feeding took place on the evening of December 19, 1886. On the following evening No. 384 was dull; on the next day it did not eat,

was dull, and its bowels relaxed. It continued in this way, with poor appetite and manifesting general debility, until the ninth day, when it was killed for examination, which gave the following facts:

Stomach rather pale; the mucous membrane of small intestine much reddened. The mucosa of large intestine, from cæcum to rectum, very dark red in large patches, resembling in some places punctiform and diffuse extravasations. A few whitish diphtheritic patches in the cæcum; no ulceration. On section of kidneys a moderate number of punctiform extravasations were found limited to the basal portion of the pyramids. Beneath the pleura the surfaces of both lungs were covered with pale red spots not larger than a pin's head. On section they could also be seen. Other organs not changed. Six liquid cultures from blood and spleen remained sterile. In this case the local lesions were very mild compared with those produced by the bacterium from Illinois and the East. In order to determine whether the bacteria themselves, which had been cultivated for nearly nine months, had lost their virulence for rabbits, a black rabbit received hypodermically into the thigh $\frac{1}{4}^{cc}$ of a culture in beef-infusion peptone one day old. The culture liquid was covered by the usual membrane characteristic of this variety.

The rabbit died January 4, 1887, five days after inoculation. The germ, therefore, was still as virulent as ever for rabbits. At the point of inoculation the blood vessels of the connective tissue and delicate fascia covering the muscles on the inner aspect of the thigh were injected and tortuous. There was no extravasation, however, and on careful inspection what appeared to be so was resolved into arborescent injections of very minute vessels. The fascia was but slightly thickened. The muscular tissue covered by it had a whitish aspect, and when cut into it was found necrosed for a depth of several millimeters and over an area of 3 or 4 square centimeters. The neighboring lymphatic of the knee-fold was enlarged and infiltrated with blood throughout. Spleen enlarged three to four times, blackish, friable. Medulla of kidneys very deeply reddened, also inner portion of cortex. Liver shows six or seven large patches of a yellowish cast, representing regions of commencing coagulation necrosis. A large number of ecchymoses of the size of a pin's head on gall-bladder; on mucous surface the membrane is blackish. Similar extravasations beneath the mucosa of the rectum for a distance of 5^{cm}, and extending upon mesorectum; one of these is a projecting hæmatoma. Caudal and cephalic regions of both lungs dark red, airless. Beneath the pleura of these regions are still darker spots or ecchymoses. The pleura covering the remainder of both lungs is dotted here and there with dark spots, varying in size from a pin's head to 10^{mm} diameter. The characteristic bacteria very numerous in spleen, less so in liver; few in blood from the heart.

A gelatine and liquid tube culture were made from the spleen and liver, and a liquid culture from heart's blood. In the tube the tracks of the needle were soon covered with colonies. In the liquid cultures only the motile hog-cholera bacteria were found. In two days every tube had a complete membrane, which became slightly thicker a few days later.

From the liquid culture prepared from the spleen one day old a large white rabbit received hypodermically into the thigh $.05^{cc}$. The culture was diluted in sterile beef broth and $\frac{1}{4}^{cc}$ containing the above amount of culture liquid was injected. The rabbit seemed well and active until it was found dead on the eighth day after inoculation. The local lesion involved only the subcutaneous tissue, in which there were ecchymoses and greatly enlarged vessels. At the place where the virus had been deposited a small nodule had formed, consisting of a whitish, pasty mass. The lymphatic of the knee fold near by was enlarged, with dark red cortex. The internal organs, markedly changed as usual, were the spleen, liver, and lungs. The spleen was many times enlarged, dark, friable, crowded with bacteria. The liver was similarly enlarged. On its caudal surface there was a diffuse discoloration, which, on closer examination, was proved to be coagulation necrosis. It had invaded the acini from the portal system, leaving the central portion still intact (Plate VI, Fig. 2). On the cephalic aspect this network of necrosis was replaced by larger solid yellowish white masses. In two places near the border of the liver the necrosis involved five to six contiguous acini, converting them into pale hyaline cylinders. The entire parenchyma was thus more or less changed, as shown on section. The cut surface presented the same interlobular trabeculæ of dead tissue. The bacteria injected were very numerous in this organ. The lungs were generally emphysematous. The margins were dark red, with darker points, probably hemorrhagic. On section these were found throughout the lung tissue for $\frac{1}{2}^{cm}$ from the border. Bacteria in moderate numbers. Two liquid cultures from spleen and liver contained on the following day the injected bacteria, with the membrane beginning to form.

The disease caused by this germ in its duration, symptoms, and lesions, in rabbits and mice, cannot be distinguished from that caused by the bacterium of Eastern hog-cholera. It is, moreover, entirely different from rabbit septicæmia,* in which no great enlargement of the spleen, no coagulation necrosis in liver, nor inflammation of lungs is present.

Pig No. 384, fed with No. 383, was dull on the following day, with relaxed bowels. It remained more or less unthrifty for several weeks after feeding.

Thus far the feeding experiments had not been conclusive, and a final attempt was made, which proved successful.

A flask containing between 500^{cc} and 600^{cc} of sterile beef infusion was inoculated from a culture (rabbit), and after standing six days in the incubator the entire amount was given to a pig which had not been fed for thirty-six hours. The culture liquid was covered with a thin membrane, and on microscopic examination contained only the motile bacterium. The animal became dull and weak, eating little. The bowels were loose on the fourth day. On the fifth it was unable to rise, and on the sixth it was found dead. The autopsy notes are briefly as follows:

In abdominal cavity several hundred cubic centimeters of a reddish serum, a thin translucent exudate covering the peritoneum of the intestine, which is diffusely reddened. Between the layers of the mesentery, along the line of attachment to small intestine, an abundant translucent gelatinous exudate. Spleen very dark on section; the surface dotted with elevated points of extravasated blood. Liver congested. Lungs normal with exception of a few lobules, which are simply collapsed.

Almost the entire digestive tract was found involved. Around the cardiac orifice a zone of mucous membrane about two inches in width was covered with whitish diphtheritic patches. Isolated ulcers in duodenum. About 6 or 7 feet of the lower portion of the small intestine very much thickened, the mucous membrane covered with a thin sheet of necrosed tissue, whitish, brittle. The cæcum and portion of the colon greatly thickened, and covered with a thick layer of necrosed tissue very rough and brownish. Near rectum necrosis gives way to closely set, isolated, roundish diphtheritic elevations of a whitish color, which leave a raw surface when scraped away.

These lesions were therefore as intense as any produced by feeding pure cultures of hog-cholera bacteria obtained from the East. The identity of the two bacteria from Nebraska and the East was thus completely established.

In the liver and spleen the bacteria were few, for a cover-glass preparation from each organ did not show any after some searching. Liquid cultures from the blood (heart), spleen, and liver were turbid on the following day, and all contained the motile oval bacterium. Within four days complete membranes had formed on the surface. The differential character of the bacterium had not changed, therefore, in passing through the organism of the pig. That the bacteria were very few in blood from the heart was indicated by a gelatine tube which had been inoculated several times with a platinum wire dipped in blood; no colonies were visible on the fourth day. Of three liquid cultures, each inoculated with a loop of blood, two remained

*Journ. Comp. Medicine and Surgery, VIII (1887), p. 24.

sterile. It was presumed that the liver would contain the largest number, inasmuch as the portal circulation received its blood from the seat of the disease. This assumption was confirmed by the very abundant colonies surrounding a piece of liver tissue which had been dropped into a tube of nutrient gelatine.

In order to make certain of the pathogenic powers of the cultures obtained from this case of feeding the tube culture from the liver was used to infect two rabbits. The skin on the inner aspect of one thigh was carefully shorn and disinfected with .1 per cent. corrosive sublimate. An incision was made through the skin, and with a loop dipped in the surface growth of the culture a minute quantity was introduced into this pocket. The larger of the two rabbits was found dead on the fifth day. The lesions were briefly as follows:

Slight amount of pus at the place of inoculation. Neighboring inguinal glands enlarged and infiltrated with blood throughout. Surrounding vessels much injected and very tortuous. Liver very friable, spleen dark and enlarged; both dotted with points and stellate spots of coagulation necrosis, especially numerous on the caudal surface of the liver. Both organs contained the bacteria of hog-cholera in large numbers. Lungs deeply congested, perhaps hypostatic. A small number of ecchymoses beneath pleura; very few bacteria in kidneys and heart's blood.

The second rabbit was found dead on the sixth day. The lesions were the same, if we except the more pronounced coagulation necrosis in the liver (Plate VI, Fig. 1) and its absence in the spleen. The bacteria of hog-cholera were distributd as above; very abundant in spleen and liver; lungs normal.

Gelatine-tube cultures from spleen and liver of these rabbits confirmed the microscopic examination. Liquid cultures from the blood contained the motile bacteria, which had formed a brittle surface membrane on the second day.

Differential characters of the hog-cholera bacterium from Nebraska.—The bacterium, when stained on cover-glass preparations from the spleen and other viscera, closely resembles the one found in the disease prevalent in the East, so that it is impossible to distinguish them in this way. Both stain well in an aqueous solution of methyl-violet in from two to five minutes, and show a well-stained narrow periphery around a pale center. This may be due to the presence of a dense envelope obstructing the inward movement of the coloring matter. In the last report an opinion was expressed that it might suggest the presence of an endogenous spore, but that the other evidence did not seem to warrant such a view. The experiments of the present year have not changed these views. The illustrations given in the last report apply equally well to the microbe from Nebraska.

A few minor differences revealed in the various culture media indicated that the two microbes were not alike in every way, and brought up the very interesting question of the variation of species of bacteria and the influence of such variation on the severity of epidemics.

The first difference was observed in liquid cultures. Within twenty-four hours after inoculation from the spleen or blood the culture liquid became turbid, and upon its surface a complete membrane was present in nearly every case. This whitish membrane is not homogeneous, but made up of patches of varying thickness, and when shaken, slowly settles to the bottom in lumps and flocculi. The microbe of Eastern outbreaks does not form a membrane within several days after inoculation, and then only when the tube remains perfectly quiet. It appears as a whitish ring attached to the glass,

and is rarely found covering the entire surface. When a number of successive inoculations are made a week apart the later cultures are quite apt to form membranes after a few days' standing. Thus one microbe forms a membrane very speedily; the other only occasionally, and then quite tardily.

In these liquid cultures both exhibit, during three or four days after inoculation, *very active spontaneous movements*. Sometimes masses of five to ten bacteria may be seen moving actively to and fro and at the same time revolving about themselves.

In the same culture liquid the microbe from Nebraska seemed to grow more vigorously, so that at the end of two or three days the liquid became turbid, and the deposit in the bottom of the tube was very abundant after one or two weeks.

Both fail to liquefy gelatine. A very slight but significant difference was observed in this medium also. It was found that when line cultures were made on plates of gelatine, in order to test the purity of liquid cultures, the microbe from Nebraska failed to develop, while the microbe from the East invariably grew as described in the preceding report. This observation was made so uniformly with every culture that it became later a means of distinguishing the two forms when the cause of this behavior became known. Such lines, after a few days, appeared as an aggregation of mere points under a 1-inch objective, and did not enlarge, or else there was no indication of any growth whatever.

Later, another quantity of nutrient gelatine was prepared, which, on boiling, threw down a very fine precipitate, uniformly clouding the gelatine. A few drops of acetic acid added to it when liquefied by heat dissolved the precipitate completely. It seemed probable that the precipitate was some alkaline phosphate or carbonate, and in fact the reaction with litmus paper was more alkaline than with the gelatine previously used. In this medium the bacterium from Nebraska grew very well both on plates and in tubes, and the bacterium from the East grew much better than in the previous preparation of gelatine, thus showing that an alkaline medium is best for the bacterium of hog-cholera, and that the Nebraska variety is by far the more sensitive, and fails to multiply unless the reaction is fairly alkaline. On gelatine plates the colonies are somewhat darker and more coarsely granular when viewed by transmitted light than those which develop from the Eastern variety.

On the surface of beef-infusion peptone agar-agar made slightly alkaline with potassium carbonate both bacteria grow very vigorously when kept in the incubator at 95° to 100° F. On potato both grow as a dirty straw-colored layer at the ordinary temperature, so as not to be distinguishable. (Plate V, Fig. 3.)

From the comparative plate cultures and from potato cultures both bacteria, when inoculated into liquid media, showed the characteristic difference already mentioned. On the following day one culture would be covered with a membrane, the other not. In milk both multiply without producing any microscopic change.

This bacterium is likewise killed by a temperature of 58° C., as the following experiment shows: Five tubes containing sterile beef-infusion were inoculated from a liquid culture ten days old, obtained from a mouse. Four of these were placed in a water bath at a temperature of 58° C., and retained there for fifteen, twenty, twenty-five, and thirty minutes respectively. These, with the check-tube, were placed in the incubator. Next morning the check-tube was turbid

and the liquid capped by the characteristic membrane, consisting of the oval bacterium. The four heated tubes remained permanently clear.

Hog-cholera in Illinois caused by the same Bacterium.

A herd was found September, 1886, a few miles southwest of Sodorus, Champaign County, Illinois, in which a number of animals had already perished from what was supposed to be hog-cholera. The disease had existed for months, and the affected animals usually lingered for several weeks.

Two pigs about four months old were chosen from this lot, which were so weak as to be scarcely able to stand or move about, and killed by a blow on the head. Owing to the disadvantages of the situation no thorough autopsy could be made. In what we shall denominate No. 1 the superficial inguinal glands were very much enlarged, purplish. In the thorax the caudal portion of both lungs was completely solidified. On section the hepatization had a variegated pale red appearance. The smaller bronchi were plugged with a white tenacious mass. A few bands loosely attached the lungs to the costal pleura. In the abdominal cavity the various organs seemed of normal size and color. The large intestines were filled with dry hard fecal masses. On opening them about four or five ulcers, ½ inch across, were found in the cæcal portion; the mucous membrane itself was pale, with a few specimens of *trichocephalus* attached to it. The stomach was emply, the mucosa pale, and pyloric region bile-stained.

In No. 2 the lungs were in the same condition, the pleurisy slightly more marked. In the abdomen the spleen was four or five times the normal size, very soft, and gorged with dark blood. In the small intestines lesions caused by *echinorhynchi* were present. In the intestine, which was empty, the only lesion noticeable was a patch of ulceration involving the mucous crypts at the base of the ileo-cæcal valve. Stomach as in No. 1.

The major portion of the spleen of No. 1 was removed with sterile instruments and transferred to a sterile bottle plugged with cotton wool. Within four or five hours bits of this spleen were carefully excised after thoroughly scorching the surface with a heated platinum spatula, and placed in tubes containing nutrient gelatine. Cover-glass preparations gave negative evidence as regards the presence of bacteria. Within two days minute whitish points could be seen in the depths of the gelatine. The hot weather had liquefied the gelatine and allowed the bit of spleen to sink into it. Small surface patches of a very gelatinous appearance were also present. On returning to the laboratory at Washington the colonies in the four gelatine tubes thus prepared were found to be made up of the oval motile bacterium of hog-cholera, identical with the bacterium described in the preceding report microscopically and in its growth in gelatine and other culture media. There was not even a single differential character by which this germ might be distinguished from the one demonstrated to be the cause of hog-cholera last year.

In order to test its pathogenic effect on small animals and to make comparisons a number of animals were inoculated simultaneously from the same liquid culture. This was obtained as follows: One of the original gelatine tube cultures was used as the starting-point and from it a liquid culture inoculated. On the following day a gelatine-plate culture was prepared from this, and when the colonies had de-

veloped sufficiently a tube of beef-infusion peptone was inoculated from one of them. In this way a liquid culture was obtained from the progeny of a single germ, although the preceding cultures had been found pure.

Three days later (October 4) the following inoculations were made: Two mice, $\frac{1}{8}^{cc}$ each; 1 guinea-pig, $\frac{1}{4}^{cc}$; 1 pigeon, $\frac{3}{4}^{cc}$; 2 rabbits, $\frac{1}{8}$ and $\frac{3}{16}$ respectively; and 2 pigs, 5^{cc} and 3.5^{cc}. Of these animals the pigeons, the guinea-pig, and the pigs remained well. One of the mice escaped several days after inoculation; the other remained apparently well until October 18, two weeks after inoculation, when it was found dead. This long period of incubation and sudden death were characteristic of hog-cholera. An examination confirmed the nature of the disease. The spleen was enormously enlarged with a mottled grayish and bright-red surface. The liver very large, dark red, and dotted with minute whitish points of coagulation necrosis, found so uniformily in inoculated mice last year. Both liver and spleen contained the oval bacterium in large numbers. The lungs were deeply congested.

Both rabbits succumbed on the seventh day, about eight hours apart. The lesions were also the same as those observed heretofore. In No. 1, at the place of inoculation, there was a small area about $\frac{1}{2}$ inch in diameter over which the fascia covering the muscles was infiltrated and thickened. There was no peritonitis, but the fat about the kidneys contained patches of injected capillaries. The spleen was very much tumefied, its dimensions being 6^{cm}, 1^{cm}, $\frac{1}{2}^{cm}$. It was very soft and dark. The liver was large; rather pale. On its surface were scattered whitish points and patches of coagulation necrosis, most numerous about the portal fissure. Kidneys but slightly reddened. The lungs were deeply congested; the pleural surfaces were mottled everywhere with blood-red points and patches. The stomach was normal. In the duodenum, at the pylorus, a band of hemorrhagic deposit encircled the tube. For $\frac{1}{2}$ inch farther the mucosa was covered with petechiæ.

In the spleen, liver, lung, and kidney the bacteria of hog-cholera were very abundant; in blood from the heart quite scarce. Cultures in nutrient liquids from liver and blood proved pure. The movements of the bacteria were exceedingly active when examined in a drop suspended from a cover-glass. The tube cultures in gelatine from the spleen and liver contained the same bacterium.

In the second rabbit *rigor mortis* was marked an hour after death. Locally a thick pasty infiltration had formed in the subcutaneous connective tissue, surrounded by injected vessels. The spleen, liver, lungs, and kidneys presented precisely the same lesions as were found in the first rabbit. There was a slight amount of serum in peritoneal cavity, not containing bacteria, as a tube of beef infusion inoculated from it remained sterile. The extravasation at pylorus was limited to a small patch. There was, however, a circumscribed area on serosa of large intestine covered with petechiæ. The bacteria were abundant in spleen and liver; absent in cover-glass preparations of kidney, lung, blood, and peritoneal fluid. A liquid culture of blood contained the motile bacterium only. Tube cultures in gelatine inoculated from the spleen and the liver also proved pure.

These autopsies, the microscopic examination of the organs, and more especially the invariably pure cultures from each animal, confirmed the supposition that the microbe obtained in Illinois was the same as the one causing hog-cholera in the East. The fact that neither pigs nor pigeons nor guinea-pigs died does not in the least weaken this conclusion. The experiments on preventive inoculation show clearly that large doses of liquid cultures can be borne with impunity by the majority of swine when introduced beneath the skin. The microbe may have been of a less virulent variety than the one with which inoculations were made last year. On the other hand, a most virulent case of hog-cholera was produced by feeding pure cultures, as the following notes will show:

A pig was kept without food for over twenty-four hours. A $2\frac{1}{2}$ per cent. solution of sodium carbonate in meat broth was then given to it. Of this it consumed about one liter, taking thus about 25 grams of the salt. It was then fed with about 50^{cc} of gelatine cultures and 100^{cc} of liquid cultures of the hog-cholera bacterium obtained from rabbits which had succumbed to inoculation; one was obtained from the original gelatine culture of the spleen made in Champaign County, Illinois. The animal was found dead December 4, scarcely three days after feeding. This was the briefest period of illness thus far observed. The lesions were very pronounced. Pyramids of

kidneys deep red throughout; glomeruli visible as dark points. Lungs pale, not fully collapsed. Right heart filled with semi-coagulated blood. Liver gorged with blood. Mucosa of stomach intensely reddened, especially along fundus, and covered with a thick layer of tenacious mucus. Mucous membrane of ileum similarly affected. Peyer's patches exceedingly dark red, showing through serous coat. The elevated border gives each a slightly concave boat-shaped appearance. The colon also deeply congested, almost hemorrhagic in patches, filled with a small quantity of semi-liquid feces. The rectum still filled with consistent masses. The mesenteric glands congested.

The feeding had thus produced a very severe inflammation of the digestive tract, so severe, in fact, that the animal died before the ulceration or necrosis had begun. The diagnosis was further confirmed by obtaining pure liquid cultures from the spleen, the liver, and blood from the heart. The bacteria were not sufficiently numerous in these organs to be detected by the microscope. To make sure that the carbonate of soda had no corrosive effect another animal was treated precisely in the same way by starving and feeding a solution of the salt. No ill effects whatever were manifested.

In order to test the specific pathogenic character of the bacterium obtained from this animal a large rabbit was inoculated subcutaneously with about $\frac{1}{8}^{cc}$ of a liquid culture from the blood. On the sixth day the rabbit was lying on its side; abdominal breathing very labored. It was found dead on the next day. Slight thickening of the subcutaneous tissue and fascia covering the thigh muscles at the point of inoculation. The muscular tissue covered with minute ecchymoses around the infiltrated patch. Small quantity of serum in the peritoneal cavity. Spleen very large, blackish, exceedingly friable, and crowded with bacteria. Liver enlarged; interlobular tissue pale; the entire parenchyma very soft and brittle. Dotting both surfaces of all the lobes are small grayish-white patches, involving one, two, or three, rarely more, acini, and bounded very sharply by the acini themselves. Peculiar figures are thus formed, three contiguous ones giving the patch a clover-leaf appearance. On section they are found to extend to the depth of one or several acini into the parenchyma. The great majority of these masses of coagulation necrosis involve lobules on or near the surface. Only a few are in the depths of the organ. When such a whitish mass is spread on a cover-glass and stained innumerable bacteria of hog-cholera make their appearance. The rest of the tissue is likewise crowded with them. Beneath the pulmonary pleura are large purplish patches of extravasation, which on section extend deeply into the parenchyma. The lung tissue is in general congested. Blood from the heart contained very few bacteria. No cultures were made.

A pipette filled with heart's blood from pig No. 1 (Sodorus, Ill.), as described in the first annual report, and sealed, was opened about three weeks later. Want of time had prevented earlier examination. Two liquid cultures were inoculated from the contents of the pipette, which were dark and firmly clotted, without any order whatever. On the following day both were clouded, and contained the motile bacterium of hog-cholera growing on gelatine in the same manner. One of the cultures contained in addition a streptococcus, which was eliminated by making plate cultures and inoculating fresh tubes from a single colony. A second pipette furnished a pure culture of another pathogenic microbe, probably the cause of the lung disease. This will be described in detail farther on.

From the spleen of No. 2 cultures were made as above. Small pieces were dropped into tubes of gelatine with the usual precaution. One tube remained permanently sterile. In two others liquefaction began after several days. A rather large bacillus was found in both tubes, in one associated with a microbe to be described later. Pieces of the spleen from the culture containing this bacillus alone were placed beneath the skin of two mice. Both remained well. This bacillus, therefore, had no pathogenic effect upon these animals. It was probably a germ accidentally present in the spleen during life rather than a contamination of the cultures. No further attention was paid to it.

The bacterium of hog-cholera was not therefore obtained from the

spleen of No. 2. Nor was it present in a pipette of blood obtained from the heart. The autopsy notes will indicate that the intestinal lesions were limited to a single patch of ulceration at the base of the valve. Whether this was due to hog-cholera cannot be said. Nevertheless the absence of the bacterium of hog-cholera from the internal organs in chronic cases, or its great scarcity, has been a matter of common observation in our investigations of this disease. The disease is in fact over, and only the lesions remain. It resembles in this respect typhoid fever in man.

The presence of another microbe in this animal, however, even more virulent in its effects upon animals than the bacterium of hog-cholera, gives it a peculiar interest, as indicating the existence of two totally distinct diseases in the same herd and even in the same animal.

To illustrate the negative results often obtained in this disease it seems advisable to give the *post mortem* notes of another case of genuine hog-cholera observed at a place but a few miles from the herd from which Nos. 1 and 2 were taken. In this herd the animals were slowly dying of a chronic malady lasting weeks. None of those alive seemed very ill excepting one, which, when incited to run, would move a short distance and then lie down. Yet when an attempt was made to catch it it showed considerable strength, scarcely warranted by the extensive lesions found at the autopsy. It was killed by a few blows on the head. The following facts were noted down:

The superficial inguinal glands very large and of a pale red. In the peritoneal and pericardial cavity a small quantity of serum; blood clots readily; lungs normal. In the cæcum the mucous membrane is converted into a continuous yellowish necrotic layer. The remaining portion of the large intestine, containing but little food, is studded with isolated ulcers from 1^{cm} to 2^{cm} ($\frac{1}{4}$ to $\frac{1}{2}$ inch) across, showing on the surface concentric brownish and yellowish rings. These ulcers are visible as opaque whitish patches under the serous coat, which are surrounded by zone of newly formed injected vessels. The ulceration, being thus deep, indicated a disease of some weeks' duration. These lesions accorded very well with those observed at the Experimental Station.

The spleen, which was preserved in a sterilized bottle, contained no germs visible on cover-glass preparations. A pipette of blood was sterile, neither liquid nor solid cultures manifesting any growth after inoculation. Of about six tubes of gelatine, each containing a bit of spleen tissue, all but two remained permanently sterile. One of these contained a feebly growing motile bacillus, harmless to both mice and rabbits. The other contained a liquefying microbe not further examined.

EXPERIMENTS DIRECTED TOWARDS PRODUCING IMMUNITY.

On page 219 of the Second Annual Report of the Bureau of Animal Industry an account is given of an experiment demonstrating the very important fact that pigeons may be made insusceptible to the strong virus of hog-cholera by the subcutaneous injection of liquid in which the bacteria had multiplied and had afterwards been destroyed by heat.

In order to confirm the remarkable result there obtained a second experiment was tried in the same way. Three pigeons were inoculated at three different intervals indicated in the table below with 1^{cc} of heated culture liquid in which the bacterium of hog-cholera

had been multiplying for sixteen, eleven, and fourteen days, respectively. Three additional pigeons received only two doses from cultures sixteen and fourteen days old, respectively. The culture liquid used was beef infusion containing 1 per cent. peptone. The tubes described in the First Annual Report of the Bureau were used unless otherwise stated. The liquid was injected beneath the skin covering the pectorals on both sides of the keel. Three pigeons were reserved as a check upon the experiment. All heated cultures used were tested by inoculating fresh tubes, which remained invariably sterile. Six days after the last inoculation with heated virus the nine pigeons were inoculated each with $\frac{3}{4}^{cc}$ of the eighth culture, two days old, from the spleen of pig No. 156. On the following day two of the three check pigeons were found dead. The rest were apparently undisturbed. The third check pigeon, which was not affected by the inoculation, differed from the rest of the pigeons in having a differently shaped trunk, a long curved beak, large ruffled masses over the nostrils, and nearly invisible iris. It was snow white. It was supposed to have some of the characters of the carrier pigeon. Leaving this bird out of account, this experiment was as conclusive as the preceding in demonstrating the protective power of devitalized cultures.

In the two dead pigeons the pectorals presented a parboiled appearance over an area about 2^{cm} by 3^{cm} (1 by $1\frac{1}{2}$ inches). On section the discoloration extended into the muscular tissue for from $\frac{1}{4}$ to $\frac{1}{2}$ inch. Nothing characteristic in the internal organs. In both the œsophagus was filled as far as the pharynx with regurgitated food. This phenomenon had been observed in former cases.

Number of pigeon.	February 19, inoculation with heated virus.	February 24, inoculation with heated virus.	March 2, inoculation with heated virus.	Total.	March 8, inoculation with strong virus.	Remarks.
	cc.	*cc.*	*cc.*	*cc.*	*cc.*	
16	1	1	$\frac{3}{4}$	$2\frac{3}{4}$	$\frac{3}{4}$	Well for several weeks after.
17	1	1	1	3	$\frac{3}{4}$	Do.
18	1	1	1	3	$\frac{3}{4}$	Do.
19	1	....	1	2	$\frac{3}{4}$	Do.
20	1	....	1	2	$\frac{3}{4}$	Do.
21	1	....	1	2	$\frac{3}{4}$	Do.
22	....	....	....	....	$\frac{3}{4}$	Dead March 9.
23	....	....	....	....	$\frac{3}{4}$	Do.
24	....	....	....	....	$\frac{3}{4}$	Well.

Since the product formed during the growth of the bacteria is not destroyed by the heat necessary to destroy the life of the bacteria themselves, it became necessary to determine whether the evaporation of the culture liquid in a water bath at the temperature of boiling water would destroy this product.

Recent investigations point to an alkaloid or ptomaine resulting from the multiplication of bacteria in liquids. It seemed advisable, therefore, to determine whether the substance producing immunity in pigeons was related to or identical with the ptomaines thus far examined. If the boiling temperature destroyed the power of producing immunity, the substance possessing this property must either be easily volatile or decomposed at this temperature. The cultures used were renewed from day to day, so that the seventh culture would

indicate that the seventh tube had been inoculated from the sixth, and that the original culture from the spleen of the animal was not more than seven or eight days older than the seventh.

In the following experiment two pigeons received two injections of heated cultures, two received injections of cultures which had been evaporated on a water bath to one-half or one-third the original volume and restored to this volume by the addition of sterile distilled water, and two were reserved as checks. The cultures used were from eighteen to twenty-three days old. All received these injections beneath the skin of the right pectoral. Five days after the second inoculation each received beneath the skin of the left pectoral $\frac{3}{4}^{cc}$ of the ordinary unattenuated culture. On the following day one of the check pigeons was dead and one sick, as shown by the ruffled plumage and quiet position. Those which had received the heated culture were both well and remained so. Of the two which had received the evaporated culture one was well, and the other sick, which died two days later. From the blood from the heart a pure culture of the bacterium of hog-cholera was obtained. A few bacteria were found in cover-glass preparations of the liver and blood. The dead muscular tissue of the pectoral was already beginning to separate as a sequestrum.

This experiment seemed to point to a partial destruction of the element producing immunity during the process of evaporation.

Number of pigeon.	April 26.	April 29.	Total.	May 3, inoculation of strong virus, twelfth culture, two days old.	Remarks.
				cc.	
30	$1\frac{1}{2}^{cc}$ evaporated culture.	$1\frac{1}{2}^{cc}$ evaporated culture.	3^{cc} evaporated culture.	$\frac{3}{4}$	Sick May 4; dead May 6.
31	....do	....do	....do	$\frac{3}{4}$	Well.
32	1^{cc} heated culture.	1^{cc} heated culture.	2^{cc} heated culture.	$\frac{3}{4}$	Do.
33	....do	....do	....do	$\frac{3}{4}$	Do.
34				$\frac{3}{4}$	Dead May 4.
35				$\frac{3}{4}$	Sick May 4; recovered May 12.

A number of other experiments were made, which are tabulated below. In some the culture liquid was evaporated on the water bath to dryness and again diluted in sterile water. In others the culture liquid was simply heated to 58° C. to devitalize it. This was tested, as before, in every case by inoculating sterile infusions therefrom. In a few experiments the age of the culture was limited to three days.

The results of these experiments show that evaporated cultures are less efficacious than heated ones; also that a single injection is not protective. A period of two days between consecutive inoculations seems to be sufficient to protect. It will be observed that the experiments were most uniformly successful in the winter. As the warm weather approached the birds became less susceptible, so that the checks failed to take the disease in some experiments. In the winter they usually died within twenty-four hours after inoculation with strong virus. Grains of corn in the beak and œsophagus indicated partial regurgitation of food from the crop. Later on the birds

lived longer. The feathers became ruffled and gave them a puffed appearance. They stood in a corner of the coop with head drooping, the tips of the wing separated from each other more than normally, the tail feathers touching the ground. The birds were conscious of movements about them, and would, when approached, regain for a time their normal position, relapsing into the former relaxed attitude soon after.

Experiments with pigeons.

Number of experiment.	Number of bird.	Heated virus, 7 to 8 days old.		Strong virus.	Remarks.
		May 29.	*May* 31.	*June* 2.	
I	1	1 cc.	1 cc.	.75 cc.	Well June 9.
	2	1	1	.75	Do.
	3	1	1	.75	Slightly ill; recovered June 9.
	4	....	....	.75	Ill next day; dead June 7.
		May 26.	*May* 29.	*June* 1.	
II	1	1 cc.	1 cc.	.75 cc.	Ill after first inoculation; very thin; dead June 8.
	2	1	1	.75	Became sick June 3; still worse June 9; dead June 12.
	3	1	1	.75	Well June 9.
	4	....	....	.75	Do.
		Evaporated virus, 7 to 8 days old.		Strong virus.	
		May 29.	*June* 1.	*June* 4.	
III	1	1 cc.	1 cc.	$\frac{3}{4}$ cc.	Well June 9.
	2	1	1	$\frac{3}{4}$	Do.
	3	$\frac{1}{4}$	1	$\frac{3}{4}$	Do.
	4	....	....	$\frac{3}{4}$	Sick June 5; still so June 9; dead June 14.
		Heated virus, 7 to 8 days old.		Strong virus.	
IV	1	1 cc.	1 cc.	$\frac{3}{4}$ cc.	Well June 9.
	2	1	1	$\frac{3}{4}$	Do.
	3	1	1	$\frac{3}{4}$	Do.
	4	....	....	$\frac{3}{4}$	Dead June 5.
		May 26.		*May* 28.	
V	1	1 cc.	....	1 cc.	Very sick June 2; dead June 3.
	2	1	....	1	Very sick June 2; recovered June 9; dead June 13.
	3	1	....	1	Well June 3.
		Evap. virus.	Heated virus.	Strong virus.	
		May 26.	*May* 29.	*June* 1.	
VI	1	1 cc.	1 cc.	$\frac{3}{4}$ cc.	Very slightly ill, but apparently well June 9.
	2	1	1	$\frac{3}{4}$	Do.
	3	1	1	$\frac{3}{4}$	Do.
		Evap. virus.	Evap. virus.	Strong virus.	
VII	1	1 cc.	1 cc.	$\frac{3}{4}$ cc.	June 20, well; July 1, well.
	2	1	1	$\frac{3}{4}$	Do.
	3	1	1	$\frac{3}{4}$	Do.
	4	....	....	$\frac{3}{4}$	Slightly ill.
		Heated virus.	Heated virus.	Strong virus.	
		June 12.	*June* 15.	*June* 18.	
VIII	1	1 cc.	1 cc.	$\frac{3}{4}$ cc.	Well July 1.
	2	1	1	$\frac{3}{4}$	Do.
	3	1	1	$\frac{3}{4}$	Do.
	4	....	....	$\frac{3}{4}$	Do.

In order to determine whether such very susceptible animals as rabbits and guinea-pigs could be made immune by heated cultures three rabbits were selected, two of which were inoculated with heated cultures and the third kept as a check. The culture liquid used consisted of about 2 per cent. Liebig's meat extract and $2\frac{1}{2}$ per cent. peptone, neutralized with sodium carbonate. Contrary to the former method, the cultures were made in Erlenmeyer flasks, and the liquid was not more than 1^{cm} deep. Considerable evaporation took place through the cotton-wool plug, which was covered with tin-foil. Thus it was presumed the bacteria would multiply more abundantly because of the greater amount of air to which the surface of the liquid was exposed. When the cultures were fourteen days old they were heated to 58° C. to destroy all life, their sterility subsequently being tested by reinoculation into fresh tubes. Rabbits Nos. 3 and 4 received subcutaneously into the thigh on April 24 and 28 and May 1 1.5^{cc} of this culture liquid. May 6 the three rabbits (Nos. 2, 3, 4) were inoculated subcutaneously with an equivalent of $\frac{1}{300}{}^{cc}$ of a fourteenth culture of the bacterium of hog-cholera. Nos. 2 and 3 were found dead May 12. No. 4 died on the morning of the same day.

All, therefore, succumbed to the inoculation with strong virus in about six days, those having received about 4.5^{cc} of the heated culture as quickly as the check animal.

In No. 2 (check) there was slight necrosis of the muscular tissue at the place of inoculation. Small amount of serum in the peritoneal cavity. Spleen enlarged, very dark, and friable. The bacterium of hog-cholera was present in large numbers in cover-glass preparations of the spleen and liver, fewer in kidneys, the cortex and pyramids of which were deeply congested. A liquid culture from the heart was found pure microscopically and when grown on gelatine plates.

In rabbit No. 3 local necrosis more pronounced than in No. 2. Ecchymoses on the contiguous wall of the abdomen. Large intestine loosely adherent to bladder, the latter to abdominal wall; mesenteric vessels distended with blood; spleen very soft, dark; bacterium of hog-cholera very numerous in spleen, less so in liver. A gelatine tube culture from the spleen pure.

In No. 4 the local lesion was similar to that in Nos. 2 and 3. The liver studded throughout with very small punctiform or stellate grayish-white masses of coagulation necrosis. A large abscess filled with white creamy pus and with a well-defined wall fills the major portion of the right lung. Several small abcesses present. The bacteria of hog-cholera were abundant in spleen and liver. A liquid culture of blood from the heart and a gelatine tube culture from the liver were both pure cultures of the same bacterium. No immunity was thus obtained by the injection of this quantity of devitalized culture liquid.

A similar experiment was tried with three guinea pigs, the same cultures being used. Nos. 5 and 6 received subcutaneously into the thigh 1^{cc} April 21, 24, and 28. The culture first used ten days old, those used subsequently fourteen days old. May 5, one week after the last injection, the three animals were inoculated with an equivalent of $\frac{1}{4000}{}^{cc}$ of a thirteenth culture in beef-infusion peptone two days old. The check animal (No. 7) and one inoculated animal (No. 5) both died May 16, eleven days after inoculation with strong virus. They were well and active to within a few days before death, when they began to crouch together and breathe heavily. In No. 5, at the place of inoculation, two small glands were enlarged, and a cavity was found containing soft, dirty grayish material, showing no cellular structure under the microscope. It was very likely a product of coagulation necrosis. The spleen was enormously enlarged, its dimensions being 2 by 1 by $\frac{1}{4}$ inch. The liver was dotted with grayish points and patches of coagulation necrosis. Kidneys pale, soft, enlarged. Lungs of a deep red. Both liver and spleen crowded with hog-cholera bacteria. A gelatine tube culture from the spleen pure. In No. 7 the local lesions were confined to an enlargement of the lymphatics, otherwise the lesions were identical with those of No. 5. One cover-glass preparation from spleen and liver revealed no bacteria, but a liquid culture from heart's blood and a gelatine tube culture from the spleen were both pure. In both rabbits and guinea-pigs the local lesions were more pronounced in those previously inoculated with heated virus. The third guinea-pig remained well. A second inoculation with $\frac{1}{5}{}^{cc}$ of a liquid culture May 22 was also without effect, as it was well and active June 2.

Tests with heated virus on Pigs.

In order to test the effect of heated cultures upon pigs the following experiments were made March 1: Two animals (Nos. 162 and 173) received hypodermically each 9^{cc} of a second and third culture, twelve and thirteen days old, respectively, which had been devitalized by heat. March 9 a second dose of 9^{cc} was given in the same way, using a fifth and eighth culture eighteen and fourteen days old respectively. These cultures were made in beef infusion containing 1 per cent. peptone, excepting one, which contained about 2 per cent. of blood serum in place of the peptone. After the second inoculation of No. 162 a swelling appeared on one side. Both were fed with viscera infected with hog-cholera, and placed with sick and dying pigs in a large infected pen. No. 162 was found dead March 29 and No. 173 April 5. The appended table and notes give a summary of the experiment:

Number.	March 1.	March 9.	Total.	Fed.	Died.	Number days after feeding.
	cc.	*cc.*	*cc.*			
162	9	9	18	March 19	March 29	10
173	9	9	18	March 19	April 5	17

No. 162. Subcutaneous fatty tissue much reddened. Mucous membrane of stomach considerably ulcerated; of small intestine deeply congested. For 8 or 10 feet above the ileo-cæcal valve the mucous membrane of ileum is completely necrosed. Large ulcers in cæcum and upper portion of colon.

No. 173. Subcutaneous fatty tissue slightly reddened. Petechiæ under pulmonary pleura. Extravasations under serosa of cæcum and colon. Inflammatory adhesions of large intestine with walls of abdomen. A patch of extravasation beneath peritoneal layer of dorsal abdominal wall nearly 2 inches across. Spleen very much enlarged and softened. The mucous membrane of large intestine and several feet of ileum necrosed and breaking down. Fundus of stomach deeply congested.

This experiment clearly showed that this method was no protection to the animal when the latter was infected by feeding.

It now became necessary to determine whether this method would confer immunity upon animals simply exposed to the disease by cohabiting with diseased animals in infected pens. Observations made upon other diseases by investigators, and by us upon this disease, seem to lead to the inference that it frequently depends on the quantity of virus introduced into the system whether the disease will make its appearance or not. In feeding this quantity is considerable; in simple exposure in infected pens to diseased pigs the amount of virus taken into the body with the food and drink is necessarily in small and repeated doses. The following experiment was therefore planned:

Four pigs (Nos. 163, 164, 177, and 196) were inoculated March 13 with heated virus, each receiving 4½^{cc} beneath the skin of each thigh. The cultures in beef infusion with 1 per cent. peptone were about fifteen days old when heated. The second inoculation was made March 16 from a culture in an Erlenmeyer flask about eleven days old, and containing about 50^{cc} of culture liquid. Each animal received 10^{cc} as before.

March 31.—These animals, together with two check pigs (Nos. 195 and 201) were placed in a large infected pen. Within a period of three weeks from this date at least fifteen pigs died of hog-cholera

in this pen. The two check animals died on the 14th and 19th of April, respectively. Of four vaccinated animals only No. 163 showed signs of the disease, and gradually developed into a chronic case, dying of general debility on May 1. The three other vaccinated animals remained apparently well for months after, although constantly exposed to the disease in the infected pen.

Pig. No.	Vaccination.		Exposure.	Died.	Number of days after exposure.
	March 13.	March 16.			
	c.c.	c.c.			
163	9	10	Mar. 31	May 1	31 days.
164	9	10	....	....	
177	9	10	Mar. 31	July 23	3 months and 23 days.
196	9	10	Mar. 31	July 7	3 months and 7 days.
195	....	....	Mar. 31	April 19	19 days.
201	....	....	Mar. 31	April 14	14 days.

Autopsy notes.—No. 163. Spleen not much enlarged; texture firm; effusion into pericardial and thoracic cavity. Lymphatic glands enlarged, but pale; two ulcers in stomach; small intestine normal; mucosa of cæcum and colon studded with many extensive and deep, yellowish ulcerations. On cover-glass preparations of the spleen only a few bacteria could be seen. Two liquid cultures inoculated from the same organ remained sterile. No colonies appeared in the gelatine tube inoculated with blood from the heart. A few developed in the tube inoculated from the spleen.

No. 195. Spleen greatly enlarged; gorged with blood; very friable; shreds of a fibrinous exudate on serosa of intestines; much serum in abdominal cavity; petechiæ on epicardium of auricles; small anterior lobes of lung hepatized; mucous membrane of gall bladder ulcerated; extensive ulceration and inflammation of mucous membrane of cæcum and colon. Hemorrhagic inflammation of kidneys.

No. 201. Spleen but slightly enlarged; lungs extensively hepatized; intense congestion and commencing ulceration of the mucosa of large intestine; stomach and portion of ileum similarly congested. Though no bacteria were found on a cover-glass preparation, a pure culture was obtained by carefully dropping a piece of spleen tissue into a culture tube. This was tested on gelatine.

After apparently resisting the infection for several months the remaining pigs (Nos. 164, 177, and 196) were transferred to a clean pen. No. 177, not very thrifty, began to decline, and finally died July 23. Among the most prominent lesions were a plastic exudate on the epicardium and numerous large old ulcers in the large intestine. The mucosa itself was extensively pigmented. No. 196, on removal from the infected pen, seemed in good condition, but it died July 7, after some days of unthrifty condition. In this case the mucous membrane of the large intestine was pigmented, and there were what appeared to be cicatrices of old ulcerations. In all of the large serous cavities there was considerable effusion. In cover-glass preparations of the spleen there were no hog-cholera bacteria to be seen, but numerous bacilli resembling those of malignant œdema.

A second experiment was made in the same way upon Nos. 197 to 200, inclusive, and No. 157. March 24 each animal received in the thigh about 10^{cc} of a mixture of heated cultures in beef infusion with 1 per cent. peptone about fourteen days old. March 29 an equal amount was injected, one-half into each axilla, these cultures being about fifteen days old. These animals were kept until April 20, when all but No. 157 were placed in the large infected pen. From that date on pigs died almost every day of the disease, so that the infection must have been quite thorough. Unfortunately no check animal was exposed at the same time. In these animals the slight swelling at the seat of inoculation disappeared in a few weeks.

They remained well, with the exception of No. 199, which became emaciated and was found dead May 19, about one month after expos-

ure. The three remaining animals were apparently unaffected nearly two months after exposure. At this time No. 197, which appeared rather thin, was killed, to determine if any ulcerations were present. But the mucous membrane of the intestine was entirely normal, with no indications of former ulcerations.

Pig No.	Injection of heated virus.		Time of exposure.	Remarks.
	March 24.	March 29.		
	cc.	cc.		
197	10	10	April 20	Killed June 10. Healthy.
198	10	10	April 20	Well June 10.
199	10	10	April 20	Died May 19.
200	10	10	April 20	Died July 12.
257	10	10	May 25	Died June 28.

Autopsy notes of No. 199.—Slight extravasation in subcutaneous connective tissue. Spleen somewhat enlarged, filled with blood, friable; considerable effusion in peritoneal cavity. Right lung in part hepatized; pleuritic adhesions to chest-wall; hemorrhage in and about pelvis of kidney; lymphatic glands purplish; extensive and deep ulceration of the mucosa of large intestine.

Pig 197, killed for examination, was very anæmic. There was some pale serum in abdominal cavity. The kidneys and lymphatic glands showed evidence of chronic inflammation. The lungs were exceedingly pale. No evidence of inflammation or ulceration in any portion of the intestinal tract.

It must be borne in mind that these animals were constantly exposed for a period of several months to the virus of the disease, and that a continual struggle between the organism and the invading parasites must have been going on, which naturally would tend to lower the vitality. Such severe conditions as these are probably never realized among herds.

The later history of No. 200 does not, however, bear out the first supposition that complete immunity was attained. After being continually exposed in the infected pen from April 20 to June 21 it was removed to a clean pen, where it continued to grow very weak. It died July 12. The autopsy revealed a plastic pleurisy over the right lung and a fibrinous exudate upon the epicardium. The mucosa of the cæcum was extensively necrosed; in the colon the ulcers were isolated; the solitary follicles were very prominent. A small bit from the epicardial exudate was placed beneath the skin of two mice. One of them died on the eighteenth day. The spleen was greatly enlarged. Numerous hog-cholera bacteria were present in this organ and liver. The epicardial exudate of the pig must have contained but very few, for they could not be demonstrated in cover-glass preparations. The long period of time from the inoculation of the mouse to its death is also evidence of a very small quantity of virus.

No. 157, inoculated with the rest, became quite lame in the hind limbs, so that it was thought best not to expose it to the disease in the infected pen for the time being. It soon recovered its power of locomotion, and was transferred to the infected pen May 25 and removed therefrom June 28. In the new pen it grew rapidly weaker and died June 28. On *post mortem* examination the right lung was found entirely hepatized and adherent to the chest-wall. The mucosa of cæcum and colon was studded with large and deep ulcers; that of the fundus of stomach was deeply congested.

It became desirable to determine whether repeated subcutaneous

injections of heated cultures until a large amount had been introduced into the system would be more efficacious in producing immunity. For this purpose the culture liquids were concentrated, by using a 2 per cent. solution of meat extract with 2 per cent. peptone for some of the injections; for the remainder a 2 per cent. solution of peptone in beef infusion. The cultures were made in Erlenmeyer flasks, plugged with cotton wool.

The table given below gives the date of the injection and the quantity used each time. It will be noted that Nos. 191 and 194 received two, Nos. 216 and 218 three, and Nos. 219 and 221 four doses each of the heated culture liquid. The injections were made two days apart, the exposure in the infected pen and among diseased animals about one week after the last inoculation. Nos. 220, 232, and 235 were placed in the infected pen at the same time, to determine the virulence of the infection upon pigs which had not received any injection.

Pig No.	Heated virus.				Total.	Exposure in infected pen.	Remarks.
	April 20.	April 22.	April 24.	April 26.			
	cc.	cc.	cc.	cc.	cc.		
216	9	8	7½	....	24½	May 4	Died May 17.
217	9	8	7½	8	32½	May 4	Died May 19.
218	9	8	7½	....	24½	May 4	Do.
221	9	8	7½	8	32½	May 4	Died May 23.
191	....	....	10	8	18	May 4	Do.
220*	....	....	....	....	18	May 4	Died May 17.
232*	....	....	....	....	....	May 4	Died May 23.
235*	....	....	....	....	....	May 4	Died June 12.
194*	....	....	10	8	18	May 4	Died June 19.

* Checks.

All of the inoculated and control animals died within periods ranging from thirteen to nineteen days, only one living thirty-nine days, and this one a control animal. Of those that had received two doses, No. 191 died May 23 (nineteen days after exposure), with considerable ulceration in cæcum and colon. No. 194 died May 19, with extensive and deep congestion of the lymphatic glands in general, of the kidney, stomach, and large intestine. In the latter, ulceration was not yet begun. No. 216, which had received three doses, died very unexpectedly thirteen days after exposure. The lesions were of the hemorrhagic type, involving extravasations and ecchymoses of the intestinal tract, more especially of the large intestine, heart, lungs, lymphatic and subcutaneous fatty tissue. Ulceration in large intestine very slight, the congestion being intense. No. 218, treated like the former, died fifteen days after exposure. The lesions were like those of No. 216, but not so severe. Ulceration as yet very slight.

Nos. 217 and 221, which had received four injections, died fifteen and nineteen days after exposure, respectively. The lesions in No. 217, which died very suddenly, were of hemorrhagic character, the ulceration in the cæcum and colon being quite superficial. In No. 221 the ulceration was more pronounced, the general congestion and extravasation much less so.

Of the control animals the lesions of No. 220 were of the hemorrhagic type, resembling those of No. 194 very closely. In No. 232 there was extensive ulceration of the mucous membrane of the large intestine. In No. 235, which lived for thirty-nine days after exposure, the mucosa of the cæcum and upper portion of the colon was involved in complete necrosis nearly 5^{mm} thick. Beyond this the ne-

crosis took the form of isolated ulcers. Owing to the depth of the ulceration inflammatory adhesions had formed between the cæcum and adjacent organs. There was no reactionary swelling of the inoculated animals at the point of injection.

Those animals in which the disease took the hemorrhagic type succumbed very suddenly, as if the invasion had taken place in a single day. In those animals in which symptoms of weakness and loss of appetite appeared some days before death the well-defined lesions were as a rule limited to the large intestine in the form of ulcerations. The former cases represent a class in which the bacterium invades the entire vascular system; in the latter the absence of a general congestion and extravasation seems to indicate a more local multiplication of the specific disease germ in the intestinal tract.

This mode of vaccination, as shown by the results recorded, did not prove to be any protection to the animals, as they died, most of them, within a brief period after exposure from a very acute attack of the disease.

The spleen examined in about one-half of these cases contained the bacterium of hog-cholera, usually in large numbers. From a few, cultures were made in which the bacterium was found pure.

A second experiment was tried, in which each animal received hypodermically 40^{cc} of heated culture liquid in two doses. The cultures were made in beef infusion with 1 per cent. peptone, the growth being killed by a temperature of 58° C. the third day after inoculation. The flasks used were shaped like Erlenmeyer flasks, a glass cap being fitted over the flask by means of a ground-glass joint, which contracted into a straight narrow tube, plugged with glass wool. The removal of a cotton-wool plug was thus avoided, the cap being removed for inoculation. This culture flask affords better ventilation and a more rapid evaporation of the culture liquid than does the culture tube with the bent ventilating tube.

The following table gives all the facts necessary for an understanding of the experiment and its results:

Pig No.	Heated virus.		Total.	Exposure in infected pens.	Remarks.	Days after first exposure.
	June 14.	June 17.				
	cc.	*cc.*	*cc.*			
231	20	20	40	June 21	Died July 7	16
233	13	20	33	June 21	Died July 9	18
266	20	20	40	June 21	Died July 9	18
230*				June 21	Died July 8	17
267	20	20	40	June 21	Died July 6	15
268	20	20	40	June 21	Died July 10	19
269	20	20	40	June 21	Died July 10	19
270*				June 21	Died July 9	18

*Check.

It will be seen that all the experimental animals died, inoculated as well as check animals, within a few days of one another; death taking place about sixteen to eighteen days after the first day of exposure. A brief synopsis of the *post mortem* appearances will not be amiss in this connection:

In No. 231 the spleen was very much enlarged and gorged with blood. The intensely congested mucous membrane of the cæcum and colon was dotted with small

superficial ulcerations. In No. 233 the congestion of spleen, and ulceration with congestion of the large intestine, were also very marked. No. 266 presented the same lesions. The ulcers in the cæcum were from ¼ to ½ inch across. No. 230 (check) differed from the preceding cases in presenting severer lesions; greatly enlarged and congested spleen and lymphatic glands, entire superficial necrosis of the cæcum and upper portion of colon, with intense congestion of the mucosa of the entire colon and great thickening of the walls; extensive extravasation of blood beneath the mucosa of duodenum.

Of the second lot of four treated in the same way, No. 267 presented very severe lesions, consisting of intense congestion and extravasation, involving the spleen, lymphatic glands, lungs, and kidney. The left lung was almost entirely adherent to costal pleura. There was considerable hemorrhage in the pelvis of both kidneys. The large intestine was least changed, the mucosa being slightly ulcerated and containing some hemorrhagic spots and points. This animal was first to die out of this lot of eight. In No. 268 the congestion involved the lymphatic glands generally, and the mucosa of the large intestine, which was extensively necrosed in its upper portion. No. 269 resembled No. 267 in the severity of the lesions. The lungs were not affected, however, while the ulceration of cæcum and upper colon was very extensive and deep. No. 270 (check) presented extensive ulceration of the large intestine and a greatly enlarged spleen. In five cases the spleen contained the bacteria of hog-cholera more or less abundantly. In two none could be seen on one or two cover-glasses. No local swelling had developed at the points of injection in any of the inoculated animals.

In this experiment no immunity was produced, since the animals succumbed to the infection very quickly and showed themselves very susceptible, as indicated by the severe lesions of the internal organs in general.

The foregoing experiments, aimed at producing immunity by the injection of the chemical products or ptomaines, were, as a whole, unsuccessful with reference to pigs, although successful upon pigeons. If larger doses of culture liquid had been given and in separate doses extending over longer periods of time the results might have been positive even upon pigs. The cost of the culture fluid being too great to make the experiment of practical value on a large scale, no further attempts were made in this direction for the present.

As the etiology of this very virulent disease had been sufficiently demonstrated by the experiments reported last year, no particular attention was paid to a determination of the presence of the bacteria of hog-cholera by cultures. Usually the spleen was examined by means of cover-glass preparations whenever time allowed, and in most cases large numbers of the specific bacterium were present. In the many cultures from spleens made from these and subsequent cases to carry out the inoculations none other than the motile bacterium of hog-cholera appeared in these cultures. At the same time many minor experiments upon mice were made for various purposes, and in all the characteristic lesions described in the second report were found associated with the specific bacterium.

Inoculations with unattenuated cultures.

While the tests for conferring immunity upon pigs by the injection of heated virus were being carried on it was thought advisable to experiment in the same direction with the unattenuated cultures themselves. A lot of animals was at first inoculated twice with very small quantities, the period between the two inoculations being about two weeks. This time was sufficient to reveal any disease which might have been induced by the inoculations. Two weeks after the second inoculation the animal was infected either by feeding the internal organs of pigs which had died of the disease or by exposing it to

the sick and dying in an infected pen. It was soon found that the inoculations were by no means protective in whatever way the virus entered the system. Feeding usually produced cases of the most acute character and with the most severe and extensive lesions. The doses of inoculated cultures were gradually increased in quantity without yielding any better results. Of a large number of animals subjected to inoculation only five took the disease unmistakably as a consequence of the operation.

This method of protective inoculation having failed with unattenuated cultures, there seemed no necessity for attempting any investigations with attenuated cultures. The experiments, including tables and *post mortem* notes, are given *in extenso* as they were made. In reading them over it will be noticed that the virus was cultivated chiefly in liquid media, and the solid media, more particularly nutritive gelatine, were only employed to test the purity of the cultures. Whenever these cultures were used for inoculations they were previously tested on gelatine plates by drawing a platinum wire, dipped into the culture, through the gelatine layer two or three times before the gelatine had become solid. Among the hundreds of cultures thus tested in the space of several months not one was found impure. Series of cultures extending up to the tenth generation were usually carried on by inoculating fresh tubes each day. The last culture tested as described above gave precisely the same colonies as the first in all the series thus far prepared. The culture tube described in the first annual report of the bureau was used almost exclusively for these cultures in liquid media. The advantages and accessibility of cultures in liquids for purposes of inoculation; the readiness and ease with which quantities or doses may be determined, finally, certain characteristics of growth in liquids, place this method on a level with, if not above, that of solid cultures for experimental purposes. For diagnostic purposes solid media are to-day a *sine qua non* of bacteriological work.

Experiments.—Pigs Nos. 152, 167, 168, and 175 were inoculated with pure cultures in beef-infusion peptone as follows: On January 23, one drop of the seventh culture, derived from the spleen of pig No. 114; on February 8, with $\frac{1}{8}^{cc}$ from a culture derived from a guinea-pig (No. 4). Both cultures were diluted in sterile normal salt solution in such a way that 1^{cc} of fluid was injected each time. The inner aspect of the thigh near Poupart's ligament was chosen. The liquid was introduced beneath the skin into the subcutaneous tissue with a hypodermic syringe. There was no perceptible swelling at the site of either inoculation, excepting in No. 175, in which there were two nodes, each of the size of a walnut, at the seat of the first inoculation. In order to test the extent of the immunity which these inoculations may have conferred, feeding the viscera of pigs which had succumbed to hog-cholera was resorted to, the animals being transferred to the large infected pen for this purpose. Nos. 168 and 175 were fed in this way March 5, and two animals not inoculated (Nos. 158 and 159) were fed with them. All four died, the two vaccinated animals in about twenty days, the others in about fifteen days after feeding. March 13, Nos. 152 and 167 were fed with two check animals Nos. 176 and 190. These four also died of hog-cholera; the two vaccinated ones averaging twenty days, the others eleven days after feeding. The inoculation may be said to have simply retarded death from five to nine days. A

table giving a summary of these facts is appended, together with a brief description of the *post mortem* appearances:

Pig No.	January 23.	February 8.	Fed with hog-cholera viscera.	Died.	Days after feeding.
	Drop.	*cc.*			
152	1	$\frac{1}{8}$	March 13	April 3	21
167	1	$\frac{1}{8}$	March 13	April 1	19
168	1	$\frac{1}{8}$	March 5	March 28	23
175	1	$\frac{1}{8}$	March 5	March 22	17
158			March 5	March 21	16
189			March 5	March 19	14
176			March 13	March 23	10
190			March 13	March 25	12

Autopsy notes.—No. 152.—Skin of limbs and abdomen dotted with purple spots; on abdomen general reddening. Points of extravasation and ecchymosed spots throughout the subcutaneous connective and fatty tissue and on gastro-splenic omentum. Superficial inguinal glands greatly enlarged and congested. Spleen enlarged, filled with blood, and very soft. Petechiæ on epicardium. Numerous lobules of the lungs collapsed. Glomeruli of kidneys appear as deep red petechiæ. In cæcum and upper portion of colon extensive and deep ulcers. A few in the ileum near the valve. The mucosa of the stomach, small and large intestine, thickly covered with dark red points or petechiæ.

No. 167.—Dying, and hence killed by a blow on the head. Spleen swollen, friable; epicardium dotted with points and spots of extravasation. In lungs a few collapsed lobules. Lymphatic glands generally very deeply congested, similarly the mucous membrane of fundus of stomach and the kidneys. Large ulcers in cæcum and upper portion of colon.

No. 168.—Subcutaneous and subperitoneal tissue contains numerous ecchymoses from $\frac{1}{8}$ to $\frac{3}{4}$ inch in diameter. Spleen enlarged, gorged with blood, friable. Petechiæ on epicardium. Lungs not collapsed; its parenchyma contains numerous deeply congested areas from $\frac{1}{8}$ to $\frac{1}{2}$ inch in diameter. Kidneys enlarged, with extravasations on surface and in parenchyma. Cortex of lymphatics in general deeply congested. Extensive, almost continuous, ulceration of cæcum and upper portion of colon, in part blackish, the remainder of the large intestine being the seat of severe inflammation and extravasation. Mucous membrane of stomach similarly involved.

No. 175.—Subcutaneous tissue dotted with pale red spots. Tumor at the place of the first inoculation firm throughout, pale yellowish. Superficial inguinal glands, as well of those of thorax and abdomen, with purplish cortex. Spleen tissue still firm, dotted with numerous bright red points, but slightly enlarged. Beneath the entire epicardium and endocardium many extravasations. Cæcum and upper portion of colon extensively ulcerated. Serous surface of large intestine dotted with extravasations.

No. 158.—Subcutaneous fatty tissue deeply reddened. Spleen slightly enlarged. Lymphatics in general with deeply congested cortex. Adhesive peritonitis matting the various viscera together and to abdominal walls; fibrinous and serous exudate abundant in the abdominal cavity. A few lung worms present. Cæcum and colon extensively ulcerated; rectum congested. Serous surface of this tract dotted with extravasations. Fundus of stomach deeply congested.

No. 176.—Slight reddening of skin and subcutaneous fatty tissue. Cortex of lymphatic glands in general deeply congested. Spleen much enlarged and surface dotted with numerous bright red elevated points. A few petechiæ on endocardium and epicardium. Lungs deeply congested throughout; kidneys likewise inflamed. Stomach slightly reddened at fundus. Small intestine also slightly congested. Serosa of large intestine dotted with extravasations. The mucosa of cæcum and small portion of colon one mass of necrosed tissue. Walls thickened.

No. 189.—Extensive and deep reddening of skin of abdomen, throat, and limbs. Subcutaneous tissue only slightly reddened; spleen enlarged, gorged with blood, friable. Besides the general congestion of the lungs there are small darker areas, representing hepatized lobules. Bronchial glands and those along lesser curvature of stomach swollen and gorged with blood; the other lymphatics only moderately congested. Besides a small number of ulcers throughout the large intestine the mucous membrane is deeply congested and dotted with occasional hemorrhagic points. Kidneys extensively inflamed; on section the cortex shows extravasations.

No. 190.—Considerable reddening of the skin of abdomen and ventral aspect of limbs, very slight in subcutaneous tissue. Spleen greatly enlarged; dark purple;

blood flows freely on cutting into it; very soft. Lungs contain regions of congestion and hepatizations, possibly due to the presence of a few lung worms. Lymphatic glands near stomach, the bronchial and superficial inguinal glands deeply congested. Other glands only slightly congested. Mucous membrane of stomach extensively congested; a large patch of extravasation in fundus; large intestine severely inflamed, with occasional extravasations; no ulcerations.

In these animals the lesions of a severe type of hog-cholera were manifested both by severe inflammations and hemorrhages of the viscera and the extensive ulcerations. It seems very probable that the bacteria begin their ravages after the food has reached the large intestine, where it remains for a time. The absence of anything but a small quantity of semi-liquid matter in the small intestine indicates the rapid passage of food from the stomach into the large intestine. The bacteria are protected from the gastric juice by the muscular and cellular tissue in which they are imbedded, and are thus able to pass through the stomach without being destroyed. The diagnosis of hog-cholera was confirmed in every case by finding the specific bacterium in cover-glass preparations of splenic tissue and obtaining therefrom pure cultures in liquid media and in gelatine.

In conjunction with the first series of inoculations, two pigs (Nos. 149 and 161) were inoculated at the same time, as follows: January 23, with 1^{cc} of the seventh culture in beef-infusion peptone derived from the spleen of No. 114. No reaction at the place of inoculation in No. 149; a tumor as large as a marble in No. 161. On February 8 both received a second injection of 1^{cc} of the second culture in beef-infusion peptone derived from pig No. 165. Two swellings as large as a chestnut at the place of the second inoculation in No. 149; in No. 161 also a considerable thickening was present. No. 149 was fed March 5 with four of the preceding series; No. 161 on March 13 with the remainder of the preceding series, and some to be subsequently spoken of. Both died of hog-cholera. The accompanying table and brief autopsy notes explain themselves:

Pig No.	Inoculation.		Fed.	Died.	Days after feeding.
	January 23.	February 8.			
	cc.	*cc.*			
149	1	1	March 5	March 24	19
161	1	1	March 13	April 14	32

No. 149.—Slight reddening of the skin and subcutaneous connective tissue; the nodes produced by inoculation firm, pale yellowish, only one showing softening within; spleen considerably enlarged and full of blood; ascarides in gall bladder, which is ulcerated; mucous membrane along fundus of stomach intensely congested; the mucous membrane of cæcum and upper portion of colon one mass of ulcers; in the remainder of colon they are isolated; kidneys congested.

No. 161.—Great emaciation; spleen enlarged and gorged with blood, very soft; all excepting the posterior region of each lung hepatized and the bronchi filled with a thick creamy mass, which consists almost entirely of pus corpuscles; lymphatics but slightly congested; adhesions between adjacent coil of large intestine and bladder; cæcum and colon studded with large deep ulcers; valve greatly enlarged; intense congestion of mucous membrane of fundus; cover-glass preparations from the spleen of both contain the characteristic oval bacterium. Gelatine and liquid cultures from the same organ were pure.

The comparatively large dose of strong virus used for vaccination was not capable of protecting these animals from the disease communicated by feeding. There was no suspicion of disease caused by the

vaccination when they were fed, and the time intervening was sufficient for the development of the disease from the injected virus.

Pigs Nos. 151, 169, 170, and 178 were inoculated as in the preceding experiments on February 8 and 23 with $\frac{1}{8}^{cc}$ of a beef infusion peptone culture derived from a guinea-pig and the seventh culture from the spleen of a pig in the same medium. The dose was diluted in salt solution so as to make 1^{cc} of liquid. In No. 151 the second inoculation produced a tumor about 1 inch long and $\frac{1}{3}$ inch thick. The first was scarcely noticeable. In No. 169 the first inoculation resulted in a bean-like nodule; the second produced several of the same size. In No. 170 neither inoculations showed more than a very slight swelling. In No. 178 both inoculations produced rather extensive swellings.

On being fed with the viscera of pigs known to have died of the disease all took the disease and died; two on March 13 and the remaining two on March 19, one in thirteen, one in eighteen, and two in twenty-two days after feeding. A table summarizing these facts and brief *post mortem* notes are appended:

Pig No.	Inoculation.		Fed.	Died.	Days after feeding.
	February 8.	February 23.			
	cc.	*cc.*			
151	$\frac{1}{8}$	$\frac{1}{8}$	March 13	March 26	13
169	$\frac{1}{8}$	$\frac{1}{8}$	March 19	April 10	22
170	$\frac{1}{8}$	$\frac{1}{8}$	March 13	April 4	22
178	$\frac{1}{8}$	$\frac{1}{8}$	March 19	April 6	18

Autopsy notes.—No. 151.—Purplish spots on skin of abdomen and paler ones in subcutaneous tissue. Inoculation tumor cuts like cheese; yellowish white. Extravasations under endocardium and epicardium; left lung mottled from congested areas; cortex of lymphatic glands congested; those of meso-colon and lesser curvature of stomach dark purple throughout; kidneys pale; hemorrhage into pelvis of left kidney; extravasations into mucosa of stomach; moderate number of ulcers in cæcum and colon; large quantity of blood in the lower six or eight feet of ileum and in the large intestine; clotted in the former tube, where the mucous membrane is deeply congested.

No. 169.—Small tumor on the left side, the place of the second inoculation; spleen enlarged and congested, with large hemorrhagic infarcts; considerable effusion in the large serous cavities. Besides the general congestion of lungs, there are scattered throughout its parenchyma hemorrhagic foci. Hemorrhagic inflammation of kidneys manifested by bright red glomeruli throughout its cortex; lymphatics in general deeply congested; numerous petechiæ in stomach, small and large intestine. In cæcum and colon large, deep ulcers.

No. 170.—Redness of skin of abdomen; nothing at places of inoculation; spleen enlarged, friable, full of blood; abdomen, thorax, and pericardial cavity contain much yellow serum, congestion of the lungs with darker hemorrhagic foci throughout; anterior lobes collapsed; kidneys enlarged, with a few extravasations on surface and in parenchyma; mucous membrane of stomach and intestines covered with many hemorrhagic points and spots. In large intestine, including rectum, numerous old ulcers, some 1 inch across. Lymphatics in general extensively congested.

No. 178.—Died quite unexpectedly. At the place of first inoculation two firm whitish masses; spleen enlarged, friable; its substance contains hemorrhagic infarcts; extravasations beneath both serous surfaces of the heart; congestion of lungs, with numerous darker hemorrhagic foci; lymphatic glands of abdominal cavity very dark and gorged with blood; extensive ulceration about the ileo-cæcal valve, in the cæcum, and colon; in the lower portion of colon and in the rectum numerous small extravasations. Hemorrhage into pelvis of both kidneys.

The *post mortem* determination of a severe type of hog-cholera in these four cases was confirmed by finding in the spleen of each

animal, by means of cover-glass preparations, numerous specific bacteria of this disease. Cultures in liquid media made from every spleen were found pure when examined microscopically as well as on gelatine plates. This experiment likewise proved the inefficiency of small quantities of non-attenuated virus introduced beneath the skin in preventing an invasion of the micro-organisms from the alimentary canal.

A third lot of four pigs (Nos. 117, 171, 172, and 174), between three and five months old, were inoculated as before with .2^{cc} each from the second beef-infusion peptone culture derived from the spleen of No. 159. On March 1 they were inoculated with .2^{cc} from the second culture derived from the spleen of No. 156. In No. 117 there was a slight swelling after the first and one as large as a chestnut after the second inoculation. In No. 171 a mass 1½ to 2 inches long and three-fourths inch in diameter was found at site of the first inoculation. There was but a small nodule at the place of the second inoculation. In No. 172 two lumps, like small marbles, formed after the first inoculation; after the second only a small nodule formed. In No. 174 the reaction after the second inoculation was manifested by an irregular tumor about 2 inches long and one-third of an inch in diameter, the reaction at the place of the first inoculation being less marked.

Of these four, two (Nos. 117 and 172) were fed with the viscera of pigs dead from hog-cholera, together with two control animals (Nos. 192 and 193), on March 19. The rest (Nos. 171 and 174) were simply placed in the large infected pen March 22, with those that had been fed with infectious matter. Below the result is given in a tabulated form. It shows that all the animals succumbed to the disease, those simply exposed by contact with the sick as well as those fed. Of the inoculated animals, those fed died in twenty-one and eighteen days after feeding; those exposed, in twenty-two and twenty-five days respectively. Those not inoculated died twelve and eleven days respectively after feeding. Here, likewise, we notice the prolongation of life in the inoculated pigs.

Pig No.	February 13.	March 1.	Date of feeding and exposure.	Died.	Days after exposure and feeding.
	cc.	cc.			
117	.2	.2	Fed March 19	April 9	21
171	.2	.2	Exposed March 22	April 13	22
172	.2	.2	Fed March 19	April 6	18
174	.2	.2	Exposed March 22	April 16	25
192*			Fed March 19	March 31	12
193*			......do	March 28	11
195*			Exposed March 31	April 19	19
201*			......do	April 14	14

* Checks.

The lesions found at the autopsies of these pigs are briefly as follows:

No. 117.—Extensive reddening of the skin of abdomen; great enlargement of spleen, which is gorged with blood, very soft; petechial discolorations on surface of lungs and on section; large intestine studded with broad deep ulcers as far as the rectum; a few in ileum.

No. 171.—Skin over ventral aspect of body deeply reddened; hemorrhagic spots under peritoneal covering of diaphragm and large intestine and under capsule of

kidneys; lungs congested, containing numerous dark hemorrhagic lobules; part of anterior lobes collapsed. The spleen very large, dark colored; nodes slightly raised above surface, shown on section to be hemorrhagic infarcts; lymphatic glands generally highly congested; petechial spots on surface and in cortex of kidneys; hemorrhagic foci throughout mucosa of stomach and intestines. About four large ulcers in cæcum and colon.

No. 172.—Reddening of skin of ventral aspect of body and of subcutaneous tissue generally; firm, pale yellow cheesy masses, surrounded by a thin membrane, at place of inoculation; engorgement of spleen and lymphatic glands; extravasations in parenchyma of kidneys. In cæcum and colon numerous deep ulcers, some coalesced. Mucosa of stomach generally congested, and that of intestines thickly dotted with petechiæ.

No. 174.—Deep reddening of skin of abdomen; encysted cheesy mass at site of first inoculation; great enlargement of spleen; prominent red points on surface; effusion into abdominal cavity; anterior lobes of lungs collapsed, remainder normal; lymphatics highly congested; three large ulcers in cæcum; valve thickened and ulcerated; petechiæ numerous throughout mucosa of stomach and intestines.

No. 192.—Control animal. Reddening of skin of ventral aspect of body and of subcutaneous tissue; spleen swollen, full of blood, friable. Atelectasis of the small anterior lobe of each lung; ulcers on the mucous surface of gall bladder. Cortex of lymphatic glands congested; mucosa of large intestines congested; numerous ulcers in cæcum and upper colon.

No. 193.—Subcutaneous connective tissue considerably reddened; spleen but slightly enlarged, not much softened. Mucous membrane of stomach, of large and small intestines, deeply congested; contents of large intestine fluid, chocolate colored.

In cover-glass preparations from the spleen pulp of these animals numerous bacteria of hog-cholera were found in each preparation. Both gelatine and liquid cultures from every spleen proved to be pure cultures of the bacterium of hog-cholera.

The diagnosis made on *post mortem* was thus confirmed by microscopic examination and culture.

To determine the effect of a single inoculation, on February 13 two pigs (Nos. 115 and 160) received subcutaneously each 1^{cc} of the second beef-infusion peptone culture obtained from the spleen of a pig. In No. 115 a tumor as large as a marble was found at the seat of inoculation March 9. In No. 160 the tumor was elongated, about 2 inches long and three-eighths of an inch thick. No. 115 was fed with viscera taken from cases of hog-cholera March 19. No. 160 was simply exposed to the disease by being transferred to the large infected pen. No. 115 died April 8. No. 160 recovered and was well May 6. The detailed account of this experiment is appended:

Pig No.	February 13.	Date of feeding and exposure.	Effect.	Days after feeding.
	cc.			
115	1	Fed March 19	Died April 8	20
160	1	Exposed March 22	Recovered	

Post mortem notes.—No. 115.—Firm, pale yellow tumor at seat of inoculation, encysted; center undergoing softening. Spleen tumefied, very dark and friable. A few extravasations beneath serous coverings of heart. In cortex of kidneys numerous hemorrhagic points; cystic degeneration of right kidneys; advanced ulceration of cæcum and colon; scattered petechiæ in mucosa of stomach and small intestine.

No. 160.—Was very low for a time, beginning with April 1. It was barely able to stand and its appetite was poor. It rapidly recovered, however, and was gaining flesh in May. Whether the animal was suffering from hog-cholera or from the *Sclerostoma pinguicola* (kidney worm), with which some of this lot were found affected, cannot be said.

In order to determine whether a single injection of a comparatively large quantity of culture liquid, while not inducing the disease, would

protect against the disease itself, the following experiment was performed:

Four pigs (Nos. 202, 204, 205, and 212) were inoculated April 2 with $1\frac{1}{2}^{cc}$ of a seventh culture in beef infusion with 1 per cent. peptone one day old. Four additional pigs (Nos. 206, 207, 208, and 209) received but 1^{cc} of the same culture. The remaining four of the same lot (Nos. 203, 210, 211, and 213) were reserved as checks upon the experiment. Of these, Nos. 203 and 213 had a temperature of 106° F., and hence were suspected of disease. This suspicion was soon confirmed after they had been placed in a pen alone. Both had a severe diarrhea, one dying April 11, the other April 13. The lesions were confined to the mucous membrane of the large intestine, which was dotted with numerous elevated lemon-yellow tough masses a few lines across, simulating ulcers. On close examination, however, this impression was dispelled. These tough masses were easily removed *in toto* from the mucosa, which presented a slight depression without any loss of substance. They were evidently exudates from the mucosa and perhaps diphtheritic. There were no bacteria in the blood or in a bit of spleen dropped into a culture tube. No development took place in either tube.

Of those inoculated with $1\frac{1}{2}^{cc}$, two died from the immediate effects of inoculation. No. 204 died in eleven days and No. 212 in seven days. In No. 204 a tough tumor had formed at the point of inoculation on each side. The mucous membrane of the large intestine was completely necrosed and the spleen enlarged. In No. 212 local swelling was present on one side. The stomach and large intestine were deeply congested, with points of commencing ulceration in the latter. In both animals the bacterium of hog-cholera was present in cover-glass preparations of the spleen. Nos. 202 and 205 seemed to remain unaffected by the inoculation. One month and a half later both were exposed to the disease in the large infected pen. A month later they were removed with others to a clean pen, after having apparently resisted infection. No. 202 was gradually wasting away and died July 24, more than two months after exposure. In the large intestine were cicatrices of healed ulcers and such as were healing. The severest lesions were in the lungs. Both were adherent by means of bands to the costal pleura, and were extensively hepatized. No. 205 was alive and well August 15.

Of the second lot, which had received 1^{cc} of the same culture, the results were nearly the same. Two succumbed to the inoculation, one died of infection, and a fourth survived. No. 208 died fifteen days after inoculation. Besides the inoculation swellings, enlarged and congested spleen, the mucous membrane of the large intestine was covered with extensive deep ulcers and the walls much thickened and softened. The corresponding lymphatics in the mesocolon deep purple. No. 209 died in six days after inoculation. There was general congestion and extravasation of blood in the internal organs, involving the entire mucous membrane of the alimentary tract, especially the large intestine, the lymphatics and serous membranes, the spleen and kidneys. Ulceration had not yet begun. In both animals the spleen was crowded with bacteria and furnished pure cultures of the specific germ.

Nos. 206 and 207 were not affected by the inoculation. They were exposed with the preceding lot, as indicated in the table. No. 207, after apparently resisting the contagion in the infected pen for a month, died July 18, after having been in a clean pen since June 21.

The extensive necrosis of the mucous membrane of the cæcum and upper portion of colon, with the absence of any acute inflammation elsewhere, gave evidence of a chronic case of hog-cholera. No. 206, though still alive, is emaciated.

The two remaining check pigs, which were exposed with the preceding animals in the same infected pen, both died of hog-cholera. No. 211 found dead June 21. The most marked changes were a small number of ulcers on a pale mucous membrane scattered over the cæcum and colon. No. 210 lived a month longer than its mate. The existence of hog-cholera was demonstrated by a general necrosis of the mucous membrane of the cæcum and an extensive pigmentation in the remainder of the large intestine. The lungs were adherent in places and much congested.

When we gather together the facts presented by this experiment we shall find a certain number of interesting deductions springing therefrom. In the first place we note the peculiarity of the intestinal lesions of the two animals which died from some unknown cause, presumably not hog-cholera. We next point to an additional demonstration of the specific nature of the bacterium of hog-cholera, for out of eight inoculated four died, and the age of the lesions corresponded well with the length of time elapsing between inoculation and death.

Those animals which resisted the inoculation were in part protected, as two among four were still alive on August 17, and the remaining two died, probably from effects of the ulceration, months after exposure.

Pig No.	Inoculated April 2.	Died from inoculation.	Exposure in infected pens.	Removed from infected pens.	Remarks.
202*	1½ cc. cult. liq		May 18	June 21	Died July 4.
204	do	April 13	May 18		
205	do		May 18	June 21	Alive Aug. 17.
212	do	April 9			
206	1 cc. cult. liq		May 18	June 21	Alive Aug. 11, but unthrifty.
207	do				Died July 18.
208	do	April 17			
209	do	April 8			
203†					Died Apr. 11, from some unknown disease.
210†			May 18	June 21	Died July 21, of hog-cholera.
211†			May 18		Died June 21, of hog-cholera.
213†					Died Apr. 13, from same disease as No. 203.

*These animals were one and a half months old at date of inoculation. †Checks.

Having determined that even large doses of liquid cultures of the bacterium of hog-cholera can be borne without producing the disease in most cases, it was thought advisable to make two inoculations of strong virus, a first one with a small quantity and a second with a large quantity.

First inoculation, April 21: Nos. 214, 227, 223, and 222 received $\frac{1}{4}^{cc}$ of a third culture in beef infusion containing 1 per cent. each of peptone and glucose. The liquid was diluted with sterile salt solution so as to make $\frac{1}{2}^{cc}$. It was injected one-half beneath the skin of each thigh.

Second inoculation: After waiting two weeks in order to determine whether the inoculation had not produced the disease, a second injection was practiced May 6, the thirteenth and fourteenth culture of the same series being used for this purpose. The animals received

1^{cc}, $1\frac{1}{2}^{cc}$, 2^{cc}, and $2\frac{1}{2}^{cc}$, of the culture liquid respectively. No untoward results following the injection of these large doses, they were transferred to the large infected pen May 25.

A second lot (Nos. 226, 228, 215, and 229) were treated in precisely the same way and at the same time, excepting in receiving $\frac{1}{2}^{cc}$ for the first dose instead of $\frac{1}{4}^{cc}$.

Pig No.	First inoculation April 21.	Second inoculation May 6.	Exposure in infected pen.	Time of death.	Days after first exposure.
	cc.	*cc.*			
214	$\frac{1}{4}$	1	May 25	July 1	37
227	$\frac{1}{4}$	$1\frac{1}{2}$	May 25	June 27	33
223	$\frac{1}{4}$	2	May 25	July 2	38
232	$\frac{1}{4}$	$2\frac{1}{2}$	May 25	July 1	37
226	$\frac{1}{2}$	1	May 25	July 3	39
228	$\frac{1}{2}$	$1\frac{1}{2}$	May 25	July 31	49
215	$\frac{1}{2}$	2	May 25	July 10	46
229	$\frac{1}{2}$	$2\frac{1}{2}$	May 25	June 27	33
224*			May 25	Aug. 4	71
225*			May 25	June 27	33

* Checks.

No. 214 being in a dying condition July 1, was killed. In the cæcum and colon were found very large, deep, blackish ulcers upon a pale mucosa. The case was evidently one of chronic hog-cholera. A pure liquid culture of the hog-cholera bacterium was obtained from the spleen.

No. 227 died June 27. The lymphatic glands were deeply congested; the mucosa of large intestine was generally pigmented and covered with large blackish ulcers. Small yellowish ulcers were also found in the ileum. The points of injection were occupied by encysted, partly liquefied masses.

No. 223 was found dead July 2. At the points of injection encysted masses were found, the contents of one of which were discharging through an opening in the skin. The mucosa of the entire large intestine deeply congested. Scattered ulcers of varying age and size in the cæcum and colon. Bacterium in spleen.

No. 222, after a period of unthriftiness, was found dead July 1. The autopsy revealed a chronic broncho-pneumonia, with pleuritic adhesions of right lung. The mucous membrane of the cæcum and colon, besides being studded with a large number of broad shallow ulcers, was deeply and uniformly congested, the congestion involving also the lower portion of the ileum. On both thighs an encysted semi-liquid mass indicated the seat of the inoculation. This case suggests the probability of a double infection, the first represented by the ulceration, the second by the more recent inflammation of the mucous membrane.

Of the second lot, which had received $\frac{1}{2}^{cc}$ of the first inoculation, all succumbed to the infection. No. 226 died July 3. The characteristic lesion was extensive ulceration, together with deep congestion of the mucosa of large intestine. Encysted masses at the points of inoculation. A considerable number of bacteria of hog-cholera in the spleen.

No. 228 died July 13. In this animal the mucosa of cæcum and colon presented a continuous mass of necrosed blackish tissue, the ileo-cæcal valve being enlarged to twice the nomal size. A few scattered yellowish ulcers in the lower portion of the colon. No. 215 died July 10, probably affected in the same way, though no *post mortem* examination was made.

No. 229 died June 27. In this case the lymphatic glands were in general deeply congested; ecchymoses beneath the serous membranes. Pigmentation of the mucous membrane of the stomach, duodenum, ileum, and large intestine from former extravasations. Several large ulcers on the valve and some others in colon. Ulcers in the cardiac portion of the stomach. Encysted masses at the point of inoculation.

Nos. 224 and 225 were penned with the above eight animals as checks. No. 225, after being sick for a few days, was found dead June 27. The mucosa of the cæcum and upper half of the colon is extensively pigmented and ulcerated, the lower half deeply congested. The ileum is also ulcerated for 5 or 6 feet from the valve. Many of the ulcers are so deep as to have produced inflammation of the serous membrane and thickening of the intestinal walls. The other check (No. 224) lived over two months after exposure, being unthrifty during this period. On *post mortem* the mucosa of large intestine was considerably pigmented and scars of healed ulcers were present. A large suppurating wound of the lower jaw, involving the bone, may have contributed towards the fatal issue.

These inoculations having failed to produce immunity from natural infection, a second experiment was tried by augmenting the dose of strong virus used for the second inoculation. Thus Nos. 239, 242, 244, and 245 received each $\frac{1}{2}^{cc}$ for the first inoculation May 27, No. 243 being retained in the same pen as a check. Of these No. 239 died of hog-cholera as the result of the inoculation. The remaining three, received two weeks later, on June 10, 2^{cc} each of strong virus. The cultures were prepared in beef infusion with 1 per cent. peptone. They were usually the third or fourth culture, not more than one day old. A second lot (Nos. 240, 254, 255, and 256) were inoculated at the same time and in the same way, with this exception, that the second dose was increased to 3^{cc}. On June 24 all were placed in the large infected pen.

No. 239 died June 2, within six days after receiving $\frac{1}{2}^{cc}$ of the culture and as a result of the inoculation. The lesions were those of a very acute case, engorged spleen and lymphatics, intense congestion of the mucosa of the large intestine and of the intestinal tract in general. The lungs were likewise engorged and dotted with extravasations. This animal was eating and apparently well on the morning of death. The spleen was crowded with the bacterium of hog-cholera, and pure cultures of the microbe were obtained from it.

No. 242 died July 17. The characteristic lesions of hog-cholera were found in it; extensive ulceration of the cæcum and colon; engorgement of spleen and lymphatic glands with blood. Encysted masses at the point of inoculation. No. 224 succumbed July 9 with practically the same lesions, besides the presence of a considerable quantity of serum in the abdominal cavity.

The check to this lot died July 13. The depth of the ulcerations in the cæcum and colon had implicated the serous covering, so that adhesions had formed between the cæcum and abdominal walls. Punctiform ecchymoses on serosa of ileum; the mucosa not affected. The mucosa of cæcum was found completely ulcerated, the necrosis stopping abruptly at the edge of the valve; in the colon the necrosis resolved itself into large isolated ulcers.

Of the second lot No. 240 died July 10. At the place of inoculation a firm pale yellowish mass about one inch long was found. The lower portion of ileum, the cæcum, the upper portion of colon, contained ulcers of different sizes. The duodenum was occluded by a clot of blood. No. 254 died the same day with lesions of a similar character. No. 255 died July 20. The spleen in this case was greatly augmented in size and gorged with blood. The right lung was congested and adherent to wall of thorax; considerable effusion in this pleural sac. The cæcum and upper portion of colon covered with deep blackish ulcers. A few small ulcers in ileum.

Pig No.	First inoculation May 27.	Second inoculation June 10.	Exposure in infected pen.	Time of death.	Days after first exposure.
	cc.	*cc.*			
239	$\frac{1}{2}$	....	....	June 2†	....
242	$\frac{1}{2}$	2	June 24	July 17	23
244	$\frac{1}{2}$	2	June 24	July 9	15
245	$\frac{1}{2}$	2	June 24	....	....
243*	....	....	June 24	July 13	19
240	$\frac{1}{2}$	3	June 24	July 10	16
254	$\frac{1}{2}$	3	June 24	July 10	16
255	$\frac{1}{2}$	3	June 24	July 20	26
256	$\frac{1}{2}$	3	June 24	....	....
253*	....	....	....	....	....

*Check. †From inoculation.

The foregoing experiments demonstrate the important fact that pigs cannot be made insusceptible to hog-cholera by subcutaneous injections of pure cultures of hog-cholera bacteria. This method, which was originally suggested and applied by Pasteur to anthrax and *rouget*, therefore fails in this disease. The experiments have been sufficiently varied and extended to leave no doubt as to this point. The subcutaneous injection of large as well as small quantities of cult-

ure liquid, either once or twice, left the animal as susceptible to natural infection as before inoculation, and in a few cases produced a virulent type of the disease. We have already dwelt upon the important fact that the disease can be produced by feeding when subcutaneous inoculation fails. This may also explain the failure of protective inoculation. The disease exerts its severest effects locally upon the mucosa of the large intestine, and in only a few cases is it a real septicæmia. The bacteria have the power of rapid multiplication within the vascular system only when exceptionally virulent. Subcutaneous inoculations of cultures, in which they may have become attenuated, are of little avail, because they are speedily destroyed in the connective tissue, leaving only a slight local swelling behind. Other lines of investigation must therefore be followed out before any practical results can be obtained.

HOW CAN HOG-CHOLERA BE PREVENTED?

The measures which must be adopted to prevent the introduction and spread of hog-cholera depend upon our knowledge of the disease as it appears in herds, and more especially upon a study of the cause. This we have demonstrated to be a microscopic plant organism belonging to the class of bacteria, and resembling in a general way those organisms which are the cause of infectious diseases among men. Of this disease the only reliable diagnostic lesion is ulceration of the large intestine, or the presence of the bacterium in the body of the affected animal, and whatever follows can only apply to the disease produced by this specific organism or bacterium.

It has been shown in this and preceding reports that the disease spreads from one animal to another of the same herd until sometimes only a small percentage of unthrifty animals remain. It extends from one herd to another, and may be carried long distances. The presence of the specific bacterium has been demonstrated in such widely different regions as the District of Columbia, Illinois, and Nebraska.

The fact that one animal takes the disease from another does not explain how the virus is transferred. Is it carried directly from one to another in the air, or is it deposited in the soil by one animal to be taken up by another? Is it introduced through a wound in the skin? Is it taken up by the lungs from the inspired air, or is it introduced with the food and drink? These questions cannot be solved by simply observing the disease in herds, hence numerous experiments detailed in this and the preceding report have been directed to a solution of these questions, upon which some rational rules for prevention may be based.

The disease is perhaps never communicated by injuries of the skin, by bites and wounds obtained in other ways. Large quantities of liquid containing the virus can be introduced beneath the skin without fatal results. In the great majority of pigs a local swelling is the only effect.

Whether the lungs serve commonly as an entrance to the virus cannot be definitely stated. All experimental evidence points the other way, and in a large percentage of cases the lungs are intact, while the large intestine is severely ulcerated. We have shown that blood and tissue which have been dried for two months may contain bacteria, which readily multiply when placed in proper media. Hence the dust from pens where the disease exists may contain many bacteria, which, on reaching the lungs, multiply and produce the disease.

It is our intention to continue experiments which may throw more light upon this mode of infection.

Perhaps the most common source of infection is the food and drink. That is, the virus enters the alimentary canal, and there produces such extensive ulceration that the animal sooner or later succumbs from gradual exhaustion, septic poisoning, or peritonitis. Or the virus immediately enters the blood from the intestines, multiplies in every organ of the body, and causes death in a few days, or even hours. Such sudden deaths usually occur at the beginning of severe epidemics. Pigs which are fed with the internal organs of those that have died of the disease almost invariably take the disease in a very severe form, and die within one or two weeks after infection. To demonstrate that it was the specific bacterium of hog-cholera in these internal organs, and not some other element, pigs were fed with liquids which contained only this organism, and they produced the most severe disease. These demonstrations, together with the commonly observed fact that the disease seems to exist in the large intestine only, prove conclusively that the virus is introduced largely with food and drink.

It has already been stated that the most common seat of the disease is the large intestine. The food after leaving the stomach passes in a liquid condition through the small intestine, so that this never seems filled; in fact, its only contents are a coating of semi-liquid matter over the mucous membrane. It passes through the small intestine quite rapidly, but on reaching the large intestine the undigested remains become more consistent, because the liquid is reabsorbed, and are kept here for some time. The bacteria, if not destroyed by the gastric juice, pass quickly through the small intestine, but in the large intestine they begin to multiply and attack the mucous membrane, which they destroy. Hence the feces or discharges of diseased pigs, wherever deposited, scatter larger or smaller quantities of the virus, which may induce the disease over and over again. The discharges, then, must be looked upon as the chief vehicle for the virus when the disease has taken hold of a herd. Pigs endowed with the well-known habits will not hesitate to avail themselves of the opportunity of becoming infected whenever it is offered. But the discharges are not the only means by which the virus is disseminated and kept alive. We have shown that the bacterium constituting the living virus is a very hardy germ, and one endowed with great powers of multiplication. In the laboratory it has grown luxuriantly in milk and on boiled potato. It grows slightly in hay infusion, even in urine not neutralized. The temperature throughout the summer in most of the States is sufficiently elevated to permit the growth of the bacterium in these various substances, since a temperature of 70° F. is amply sufficient, and temperatures above this point simply favor the rate of increase of the quantity of virus. Even in good drinking water the virus will increase for four or five days and remain alive for months.

There is consequently very little about a pen in which the virus, when scattered in the discharges of infected animals, will not increase in quantity and form a more potent source of infection. It will multiply in the wet soil, in the drinking water, and in the semi-liquid food. A gallon of milk inoculated with a minute portion of infectious material and allowed to stand through a warm night in midsummer might be sufficient to produce the disease in at least a dozen animals if fed to them on an empty stomach.

Such are the external conditions which may favor the extension of hog-cholera. The condition of the animals themselves is of great importance in favoring or preventing infection. When pigs are fed with liquids in which the specific bacterium only is present, those that have been deprived of food for some time previous take the disease, while those whose stomachs contain food that is undergoing digestion do not take it readily. If, besides starving the animal, they are fed with some alkaline solution by which the alkalinity of the stomach is increased, the pathogenic effect is still more pronounced. Any disorder of digestion by which the secretion of gastric juice is diminished or checked and the mucus is increased in quantity will increase the susceptibility of the animal to infection, because the alkalinity of the mucous membrane will favor rather than destroy the virus. Any mode of feeding which produces constipation and overdistension of the large intestine is likely to favor the disease, as the virus is retained for a longer time. It multiplies there and destroys the mucous membrane before it is discharged. Keeping these facts in mind, we may formulate a few rules, which must be carefully observed if the disease is to be kept in check.

In the first place, there should be no communication between infected herds and such as are still free from the disease. The virus may be carried in various ways, even on the shoes of persons. A small quantity thus introduced may multiply in the soil and water until it becomes a center of infection for many animals. Streams into which sick animals have dropped discharges or in which dead ones have lain must be considered as vehicles of the disease for all herds below the source of infection. This is especially true in warm weather, when the virus multiplies very rapidly and extensively.

When the disease has appeared in a herd, the ground upon which the animals lived at the time must be considered as infected, and it is much safer to remove all the well ones to uninfected grounds than to simply remove the sick ones. But how are we to know that the disease has gained a foothold in the herd? It is quite common for the disease to announce itself by a few sudden deaths. The stricken animals may seem well a day, perhaps only a few hours, before death. Such animals should always be immediately destroyed by careful deep burial, or by burning, which is much better, for the bodies are as a rule crowded with the specific poison of hog-cholera. In order to remove any doubts as to the precise nature of the disease, it is best to examine such animals before burying or burning them. This should be done in a secluded place which pigs cannot reach, and the ground thoroughly disinfected, as will be described later. The disease in the sudden cases can be easily recognized. The spleen is as a rule very black and enlarged. Spots of blood from the size of a pin's head to a quarter inch or more will be seen in the fat under the skin, on the intestines, lungs, heart, and kidneys. The lymphatic glands are purplish instead of a pale pink. When the large intestines are opened they are found covered with these dark spots of blood more or less uniformly and entirely. Often the contents are covered with clotted blood. Any or all of these may be considered as signs of the disease in its most virulent form. In these animals the virus has penetrated into all of the vital organs, and they should be immediately removed and destroyed. It must be borne in mind that for any animal to consume portions of these carcasses would be certain death; that the blood and fluids from these dead bodies contain the virus, and when scattered over the soil or thrown into

streams they simply distribute the virus, allow it to multiply, and all the other animals are thereby put in the way of becoming infected.

In many outbreaks the early cases do not succumb so rapidly. They grow weaker, lie down much of the time, eat but little; and usually have diarrhea. Most of such cases may linger for weeks, meanwhile scattering the poison in the discharges. The disease may be recognized in these cases as soon as they are observed to act suspiciously, and there should be no delay in determining at once the nature of the disease. When the animal has been opened the large intestine should be carefully slit up and examined, beginning with the blind or upper end. There will be seen roundish yellow or blackish spots, having an irregular depressed, sometimes elevated, surface. These are well shown in the Second Annual Report of this Bureau, p. 246, or in the Annual Report of the Department for 1885, p. 522. These spots correspond to dead portions of the mucous membrane, and they are frequently seen from the outside as soon as the animal is opened. Sometimes the membrane has been entirely destroyed. Its appearance is well shown on Plates I and II of this report. These slow, chronic cases are apt to spread the disease in the bowel discharges, for in them the virus is chiefly located.

Having determined the existence of the disease, it may not be possible to remove the healthy animals to uninfected quarters after the sick ones have been taken away. Under such circumstances thorough disinfection should be practiced at once. Among a large number of substances tried in the laboratory only a few were found to meet the requirements of rapidity of action combined with certainty and cheapness. Carbolic acid seems to be useless, as it is expensive, and a considerable quantity is required to destroy the germs. Thus experiments in the laboratory have shown that to kill the virus in liquids 1 part carbolic acid in 100 parts of water is required, whereas 1 part of mercuric chloride in 75,000 parts of water is sufficient. The best disinfectant is therefore mercuric chloride, also called mercuric bichloride and corrosive sublimate. As it is a violent poison to man and animals, it should be very carefully handled. In order to make a solution which is strong enough to act rapidly and with certainty, 1 part of the substance should be dissolved in 1,000 parts of water. This is best accomplished by adding half an ounce to about four gallons of clear water, preferably rain-water. As a pound of corrosive sublimate retails at about 70 cents, the cost of the disinfectant is very small. This solution, which should be made in wooden or granite-ware vessels at least half a day before use, should be applied by means of a broom or brush to the flooring, sides, and covering of pens in which diseased animals have staid. All utensils used about the pens, as well as the troughs and other things containing food, should be carefully washed with the solution and afterwards rinsed thoroughly in pure water. Ten minutes' exposure to the disinfectant solution is sufficient for all purposes. As the corrosive sublimate solution attacks many metals, iron and tin utensils should be disinfected with boiling water instead of the mercuric chloride solution.

The bowel discharges should be made innocuous by pouring upon them corrosive sublimate solution or mixing them with powdered chloride of lime. In general it may be stated that whatever has come in contact with diseased animals or their discharges should first be disinfected before healthy animals are brought in contact with them In using the corrosive sublimate solution we must bear in mind that

it is poisonous to animals as well as to man, and that to get the desired effect no large quantities need be applied. The surface need simply be moistened with it in order to be disinfected. A spray apparatus, by means of which a spray is deposited, would be most convenient, but such apparatus is expensive and not readily procurable. It is always desirable to moisten the bodies of dead animals with the disinfectant before removing them. Any virus adhering to the surface of the body is thereby destroyed and the danger of disseminating it avoided.

When the disinfectant is not at hand much can b edone with boiling water, which immediately destroys the virus. Scalding the troughs and other articles is perhaps better than the use of the corrosive sublimate, especially if they are immersed in the boiling water or flooded with it. Some good may be done by scalding bowel discharges and the flooring of pens, although by doing so the virus which is not destroyed is carried away by the cooling water, which may later on favor its multiplication. In any case it is best to use for pens the sublimate solution first and then scald them.

As it is quite impossible to disinfect the soil with any degree of certainty, it is very desirable that in a herd in which the disease has appeared the still healthy animals be transferred to fresh ground and kept confined. In this way the dangers arising from an infected soil are averted. For a like reason animals should be kept from streams which have become polluted, as it is impossible to disinfect them. Hence a dry soil, without standing pools of water, should be chosen as long as any suspicion of the disease exists.

Great care should be bestowed upon the food, especially that of a liquid character, which, when infected, will permit the multiplication of the virus and may infect large numbers. Cleanliness in this respect is perhaps the simplest and most universal rule which can be laid down. This simply means that the food should not come in contact with the bowel discharges of diseased animals; that it should not be allowed to stand for more than a few hours before it is consumed; and that the troughs used for feeding should be scalded at least twice a day when there is a suspicion that the virus may be among the animals.

It may seem too laborious or perhaps superfluous to carry out such directions as these. They may be incompatible with the present methods of hog-raising in many parts of our country. They are, however, the only means at present available by which the spread of the virus may be checked. They prevent the soil from becoming saturated with it, and every exertion made towards disinfection destroys so much, and continued efforts may finally destroy it altogether. Moreover, if the disease does appear while measures of prevention are being carried out, it is not so apt to become very destructive, for the severity of the disease depends, as a rule, upon the quantity of virus taken into the system. If this is allowed to accumulate on all sides, much will find its way into the stomach and intestines and cause the most severe disease.

We do not know whether the virus can live in the soil through the winter, but it seems highly probable. Hence thorough disinfection practiced will lessen the chances for a reappearance of the disease in the following year.

The investigations in regard to vaccination as a means of prevention have not yet led to any results which can be practically utilized, and therefore are still being carried on. The ordinary methods of

attenuation, as practiced by Pasteur in obtaining a vaccinal virus for anthrax and *rouget*, are inapplicable in this peculiar disease, for the unattenuated virus itself is incapable of conferring immunity. The experiments demonstrating this fact are found on another page. Hence any attenuated virus is still less capable of accomplishing this end.

The use of certain medicines internally to act as preventives may prove of some value, and it is our purpose to carry out some experiments in this direction as well.

The treatment of this disease, as of the great majority of infectious diseases, after it has gained a firm hold upon the animal, is not only useless but dangerous; for the animal can only serve to spread the disease. The ulcerations produced in the large intestines can only heal slowly if they are not too extensive, while medicines are of no avail. Those who insist upon a cure for well-pronounced cases of hog-cholera, in which the bowels have become ulcerated, should look upon the disease of typhoid fever in man, in which ulceration also occurs. Through centuries the best physicians have been treating this disease, yet none has ever ventured to assert that he had a cure for these ulcerations. They take the best care of the patient and allow nature to heal the ulcers. Even then they frequently find their patient snatched away at the very threshold of recovery.

PRELIMINARY INVESTIGATIONS CONCERNING INFECTIOUS PNEUMONIA IN SWINE* (SWINE-PLAGUE).

In prosecuting investigations in the West in order to determine whether the disease which has been described in these reports as hog-cholera existed there also, the lesions characteristic of this disease and the specific bacterium were found in Illinois and Nebraska. At the same time another microbe was found, resembling in its microscopical characters the microbe of rabbit septicæmia very closely, and associated with disease of the lungs—a chronic pneumonia—in the few cases which were examined. Although the investigations concerning the nature of this microbe, its distribution, and the losses it produces, are scarcely begun, we venture the conclusion that it produces an infectious pneumonia in pigs, and that its effect may perhaps be spent upon organs other than the lungs. This conclusion is based upon the facts recorded in the following pages.

Among the *post mortem* examinations made in the State of Illinois in July, 1886, the following are worthy of attention:

In Marion County, a few miles from Patoka, a herd was found, July 7, of which about ten had died and an equal number were still alive. Through the kindness of the owner several pigs, which were evidently diseased, were killed by a blow on the head. In No. 1 the superficial inguinals were greatly enlarged; ecchymoses were found in the subcutaneous fatty tissue in large numbers on the omentum and the epicardium. The lymphatic glands were as a rule enlarged and purplish, the spleen augmented in size, the major portion of the lungs hepatized, and the remainder interspersed with hemorrhagic foci. The mucous membrane of the stomach and the large intestine was ecchymosed, that of the latter presenting here and there deep ulcers, especially on the ileo-cæcal valve. Cover-glass preparations from the spleen of this case contained no bacteria of any kind. A tube of gelatine into which a bit of spleen had been dropped remained sterile. No. 2, from the same herd, also killed at the time, was affected with a suppurative pyelitis of the right kidney, causing inflammatory adhesions of the large intestine. The mucous membrane of the latter was dotted with innumerable petechiæ and a few ulcers. Cover-glass preparations

*We shall call this disease swine-plague, in distinction from hog-cholera, just described. See introductory remarks to Diseases of Swine, p. 603.

from the spleen of this animal were equally negative. A tube of gelatine into which a bit of spleen tissue was dropped began to liquefy very slowly. It contained a bacillus and a large oval coccus.

No. 3, from the same herd, killed, had its lymphatic glands generally enlarged and purplish, the spleen dotted with numerous blood-red elevated points, lungs with large carnified areas. The mucous membrane of the large intestine was merely congested. No bacteria seen in cover-glass preparations of the spleen, and a gelatine culture made as before remained sterile.

Several miles east of Champaign, Ill., the disease was appearing in a herd, the owner of which very kindly permitted us to make what examinations we thought advisable. On July 8 two autopsies were made. In No. 4, dead since last night, the lymphatic glands generally were enlarged and purplish. The subcutaneous fatty tissue stained yellow. The peritoneal and pericardial cavity contained a considerable amount of yellow serum. The only other marked lesion observed was an enormous enlargement of the spleen, which was very dark and pulpy. The mucous membrane of the alimentary canal apparently intact. These lesions did not point to hog-cholera. Cover-glass preparations of the spleen were negative. A piece dropped into a tube of gelatine slowly liquefied the latter. A bacillus was found in it, not pathogenic.

A pig (No. 5) which was observed to be very weak, although able to move about when disturbed, was killed for further information. In the subcutaneous tissue over the abdomen were numerous ecchymoses. The inguinal glands were greatly enlarged, cortex purplish, some lobules deeply congested throughout. The abdominal cavity contained a small quantity of colorless serum; the spleen considerably tumefied and covered with blood-red raised points. The lymphatic glands about the stomach, as well as the bronchials, were deeply congested, the cortex infiltrated with blood. The epicardium was dotted over its entire surface with minute extravasations. The mucous membrane in the fundus of the stomach and of the entire length of the large intestine covered with closely-set extravasations. Cover-glass preparations, as well as cultures of the spleen, were entirely negative.

Reports of swine-plague from Geneseo, Henry County, made it advisable to make a few *post mortem* examinations in this section of the State, in order to make sure of the nature of the disease. The losses were very heavy, involving in many places the greater part of the affected herd. July 11 several autopsies were made in a herd about 3 miles from Geneseo. In this herd the disease had been observed about nine days before. At the time three or four large animals had died during the night and a number of others were ill.

No. 6.—Adult black male, in good condition, no signs of decomposition. In the peritoneal cavity there were ecchymoses beneath the peritoneum of the dorsal wall, near the caudal end of the kidneys, at least an inch in diameter. The spleen was enlarged and congested. Whitish patches showing through the serosa of the large intestine were afterwards found to correspond with ulcerations of the mucous membrane. The lymphatic glands in general with congested cortex. The left lung completely solidified, blackish, and everywhere adherent to chest wall. On forcing the ribs apart the lung tissue broke as a watermelon would; from the broken surface a blackish frothy liquid exuded. A portion of the right lung was in the same condition. A fibrinous deposit on the epicardium indicative of pericarditis. In the alimentary tract the mucous membrane of the fundus of the stomach is darkened with extravasations on the ridges of the folds. In the large intestine the mucous membrane is completely covered with punctiform extravasations, in part converted into pigment. In the cæcum and colon are isolated disk-shaped ulcers about one-half inch in diameter, slightly elevated. The center is dark, surrounded by a broad yellowish margin, giving the whole a button-like appearance. On section a whitish tough tissue is found to make up the ulcer and extend to the peritoneum, where it appears as a whitish patch when viewed from the serous surface. Cover-glass preparations of the spleen negative. Two portions dropped into a tube of gelatine and agar-agar respectively gave rise to cultures which will be described n detail farther on.

No. 7.—A small shoat, having shown signs of disease for a few days, was killed by a blow on the head. The superficial inguinal glands were enlarged and reddened. Both kidneys dotted on the surface with minute petechiæ. On section a few are found in medullary portion. The spleen is dotted with a few blood-red elevated points. Cover-glass preparations of the spleen negative. Cultures remain sterile.

No. 8.—Large black sow; died last night. Adipose abundant. In this animal the spleen was enlarged, the medullary portion of kidneys deeply reddened, lungs normal. The mucosa of the large intestine was entirely covered with minute elongated spots of pigment, representing former extravasations. Cover-glass preparations of spleen also negative. A gelatine tube containing a portion of spleen contained a

micrococcus. Bits of the spleen introduced beneath the skin of the dorsum of two mice made them ill for a few days. Both finally recovered.

Besides the cultures mentioned in the autopsy notes at least ten others were made at the time by piercing the spleens with a platinum wire and then piercing with it tubes of gelatine or drawing it over the surface of tubes of agar-agar. None of these showed any signs of growth, thus confirming the supposition, derived from the examination of cover-glass preparations, that the specific microbes are either entirely absent from the spleen or else are present in very small numbers.

The lesions found in all but three cases, in which the ulceration of the large intestine was present, were not sufficiently uniform to warrant the diagnosis of hog-cholera. Viewed by the light of later observations, it seems highly probable that the remainder of the animals were affected with a different malady, due to the presence of the microbe to be described later on. The ecchymosis of the large intestine and the congestion and tumefaction of the lymphatics generally differed from the lesions which we have found in hog-cholera. The absence of bacteria from the tissues is also suspicious. There was moreover a partial cirrhosis of the liver in most of the animals examined which we have never encountered in hog-cholera. We must remember, however, that of these eight cases five were killed, perhaps in the early stages of the disease, before the lesions were well marked. Leaving these observations for future interpretation, when more cases have been examined we will proceed to a description of the bacteriological investigations.

In a few among a large number of tubes bacteria were present. Nearly all were found harmless when inoculated into animals very susceptible to hog-cholera. In two tubes inoculated with bits of spleen from No. 6 two microbes were found which deserve attention.

One grew in both tubes, which was more carefully examined, because it resembled the bacterium of hog-cholera very closely. In liquid media it is actively motile and simulates the form of a bacillus. When stained, however, each individual is resolved into a pair of ovals or very short rods with rounded extremities. A deeply stained narrow border surrounds a comparatively pale body. There seems to be slightly more stained material at the two extremities than in the bacterium already fully described in the last report. It seems a trifle longer than the latter form, but on attempting to confirm this impression by measurement the dimensions were found practically the same. Sown on gelatine plates the colonies appear within twenty-four hours and grow quite rapidly. The deep colonies are spherical, with smooth outline and homogeneous disc. The surface colonies appear as irregular patches, spreading very quickly, and, as a rule, growing far more vigorously than the deep colonies. In tubes containing nutrient gelatine the isolated colonies in the depth of the needle track may grow to the size of pins' heads. On the surface a flat, thin, pearly layer rapidly extends from the point of inoculation, and in from one to two weeks may have covered the entire surface. The margins are irregularly scalloped and lobed, the entire layer often simulating the frost flowers on windows or lace work (Plate V, Fig. 2). On potato, a thick straw-colored shining layer of nearly smooth surface forms, which grows very vigorously and gradually covers the entire cut surface of the potato with a layer 2^{mm} thick. This growth is brighter in color and more abundant than appears in the potato culture of the bacterium of hog-cholera. Cultivated in liquids, such as beef infusion with 1 per cent. peptone, the medium becomes very turbid within twenty-four hours. A thin pellicle appears, which soon becomes a thick membrane. A cream-colored deposit forms and accumulates to a considerable extent, while the liquid remains turbid. It will be remembered that the bacterium of hog-cholera grows very feebly in comparison.

No resistant spore state was found, for tubes exposed to 58° C. for fifteen minutes remained sterile; those exposed ten minutes became turbid. The pale, unstained central portion of the bacterium simulates very strikingly the appearance of an endogenous spore, yet they all succumb to the temperature of 58° C., as described. A peculiar property not common to the hog-cholera bacteria described is the coagulation of the casein of milk. If a tube of this liquid, sterilized by discontinuous boiling, be inoculated, it will be solidified within twenty-four hours. The coagulum, contracting later on, leaves a shallow stratum of watery liquid near the surface.

The reaction is acid. Grown on gelatine a rather penetrating odor of decomposing flesh is given off. The bacterium of hog-cholera develops no odor whatever in cultures. This microbe, therefore, resembled the bacterium of hog-colera very closely in its microscopic characters, but differed from it in some of its physiological properties. This illustrates how important cultivation experiments are in the determination of specific differences. That it was not the bacterium of hog-cholera was shown by an utter want of pathogenic properties when inoculated into mice and rabbits. Pigs were inoculated and fed; cultures were introduced per rectum without any effect whatever.

In one of the tubes the motile bacterium just described was mixed with another microbe, which proved to be a very virulent germ. It was obtained pure as follows: A rabbit inoculated with the mixture from a liquid culture made from the original gelatine tube died in seven days, after showing signs of lameness for several days. The inoculated thigh was enlarged, the skin bluish. The subcutaneous connective tissue was of a leathery consistency. The surface of the muscular tissue on the inner aspect of the thigh was of a uniform yellowish gray; this change extended into the muscular tissue to the depth of 3^{mm} (one-eighth inch); the striated appearance was lost. This change also involved the deeper intermuscular septa of the thigh. On the abdomen the subcutis was infiltrated with a blood-stained serum. The local effect had thus been unusually severe. Cultures from the spleen, liver, and blood in gelatine tubes contained only the second microbe. The one above described had no power of invading the tissues of the rabit. That the microbe obtained from the tissue of this rabbit was pathogenic the following experiments clearly demonstrate:

With pure liquid cultures of this microbe three mice were inoculated. Two of these died within one and two days of inoculation. In the spleen of both peculiar torula-like forms were found, presumably the cocci in process of division, which was retarded by unfavorable conditions. Its effect upon a rabbit, however, was more pronounced. This rabbit died three days after a hypodermic injection of $\frac{1}{6}^{cc}$ of a liquid culture. Beneath the skin of the inoculated thigh there was a translucent gelatinous exudate about one-half inch thick. The muscles of the thigh and of the contiguous wall of the abdomen were dotted with closely set punctiform and larger extravasations. In the abdomen they were very numerous on the large intestine along a zone nearest the abdominal wall. They were also found over the kidney and on the psoas muscle. Spleen not enlarged, dark; liver rather pale; acini well marked; the entire right lung and base of the left deeply congested; very few bacteria in the internal organs. Two liquid cultures of blood and one from liver contained the injected microbes. Gelatine cultures of blood, spleen, and liver developed into numerous colonies of the same microbe in the needle track.

Two pigs (Nos. 287 and 289) were inoculated September 11 from a culture of the rabbit. Each received beneath the skin of the thigh $2\frac{1}{2}^{cc}$ of the culture liquid. No. 287 became dull and lost its appetite several days later; eyes discharging. September 28 the animal became delirious and ran blindly about the pen; dead next morning. The only observable lesions were local swellings two inches across and one-fourth to three-fourths inch thick, with centers which were beginning to soften. Blood very dark, not coagulated; a few petechiæ on epicardium. The liver was very pale, sclerosed; the medulla of kidney deeply reddened. No. 289 died September 21, after exhibiting the same symptoms; local swellings as above, without indications of

softening; the connective tissue and fat of the whole body of a deep yellow color; liver very firm, bloodless, and of a peculiar yellowish red color throughout; medulla of kidneys deeply reddened; two large cysts in the right one. In neither case was the alimentary tract diseased. In both there was cirrhosis of the liver, producing in the second animal a general jaundice. From neither were cultures of the inoculated microbe successful, though blood from the heart, the spleen, and the liver were used. The tubes remained sterile.

Nos. 288 and 290, which had been retained in the same pen, did not contract the disease from the others, as would ordinarily happen in hog-cholera. No. 288 was fed with hog-cholera viscera October 12, and died from the effects December 4; cæcum and colon ulcerated. No. 290, fed at the same time, died October 28, the only visible cause of death being retention of urine.

This microbe was, therefore, fatal to mice, rabbits and pigs, producing in the pig an acute inflammation of the liver, leading to a marked cirrhosis and general jaundice.

The same disease found near Sodorus, Ill.—The same microbe was obtained from an outbreak in Sodorus, Ill., several months later. On page 630 a description is given of two *post mortems*, in one of which (No. 1) the lesions were ulceration of the large intestine and a grayish hepatization of the lungs. From this animal the bacterium of hog-cholera had been obtained from the spleen. In the other animal (No. 2) the lung lesions only were present. Portions of the solidified lung tissue from No. 2, hardened in strong alcohol, were submitted to a microscopic examination. The tissue was infiltrated with paraffine, the sections treated with turpentine to remove the imbedding substance, and then stained in various ways. The smaller bronchi and air-cells were completely filled with an exudate, consisting of white blood corpuscles chiefly, and some larger pale cells, probably derived from the epithelium. This infiltration was exceedingly dense in many places; in others less so. The septa or alveolar walls were not perceptibly affected, but the capillaries were distended with blood corpuscles, and formed an unstained mesh-work around the deeply stained alveolar contents. The interlobular connective tissue was also infiltrated, and the lymphatic spaces distended and filled with a fibrillar network of coagulated lymph. When the alveolar contents were carefully examined with a one-eighteenth homogeneous objective, after staining the section in Löffler's alkaline methylene blue for several hours and decolorizing in one-half per cent. acetic acid, groups of very minute oval bacteria were recognizable, in size and outline like those obtained in cultures from the pleura. These groups were very large and extended through the depth of the section, a fact easily recognized by focusing up and down. They were found in all parts of the section, the bacteria themselves and the groups they formed being readily recognizable. No other bacteria could be detected, though the sections were searched over many times. Staining in aniline water methyl violet overnight did not bring these groups out so clearly as the stain above given. These groups, moreover, were present in those air-cells chiefly in which the exudate was but moderately dense.

The lesions of the lungs found in both pigs at Sodorus, Ill., were different from those occasionally found in *post mortem* examinations of hog-cholera at the Washington Experimental Station. In the latter the acute cases, characterized by hemorrhagic lesions in various organs, usually presented lungs which were dotted with dark red

patches visible on the pleural surfaces and in the parenchyma. These were evidently extravasations into the alveoli, and etiologically the same as the extravasations found elsewhere. In the majority of cases lung lesions were entirely absent. When present they were usually associated with an abundance of lung worms in the bronchi. In many cases the small anterior lobes resting laterally upon the pericardium were collapsed (atelectasis), of the color of red flesh. This condition seems to stand in no direct relation to the disease itself.

The broncho-pneumonia found in the pigs above referred to extended over at least one-half of the lungs, involving the caudal portion of the base, resting on the diaphragm. The pleura was but slightly affected; a few adhesions and a more than normal quantity of serum on its surface constituted the visible changes. The lung tissue itself was airless, solid, of a grayish red, somewhat mottled. From the pleural surface of No. 2 two tubes of gelatine were inoculated by dipping into them a loop of platinum wire filled with serous exudate. The heat of the weather liquefied both tubes soon after, and within a few days the gelatine in one of them was densely crowded with small whitish points; in the other tube the colonies were fewer in number and consequently much larger. Both were, in fact, pure cultures of a non-motile oval bacterium, found identical in all respects with the microbe obtained from Geneseo, Ill., and already described.

Postponing the description of this microbe for the present, the following experiments were made in order to determine its pathogenic effect upon small animals:

From one of the original tube cultures in gelatine, plate cultures were made, and from one of the colonies a tube containing 10^{cc} beef-infusion peptone was inoculated. When two days old the following animals received subcutaneously portions of this culture: Two mice, $\frac{1}{8}^{cc}$, $\frac{3}{16}^{cc}$; two rabbits, $\frac{1}{8}^{cc}$, $\frac{1}{4}^{cc}$; two pigeons, $\frac{1}{2}^{cc}$, $\frac{3}{4}^{cc}$; two pigs, 4.5^{cc}, 3^{cc}. One of the mice was dead on the following day. In the spleen and liver were present oval bacteria and some quite long rods. The liquid culture from the blood remained sterile. The second mouse died in two days. A peculiar bacterium was present in spleen, liver, and blood, often irregularly fusiform and pyriform; most were cocci in pairs. A liquid culture from the blood of the heart contained the inoculated microbe only, and the identity of this germ with the one injected was confirmed by plate cultures.

Both inoculated pigeons died, one two days and the other four days after inoculation. In the former the pectoral muscle at the point of inoculation had a grayish-yellow parboiled appearance over an area of 1 to $1\frac{1}{2}$ square inches and extending to a depth of three-eighth inchs. In the second bird, which had received the larger dose, the local lesion was less marked. A thick pasty deposit had formed between the skin and muscle, slightly infiltrating the surface of the latter. No bacteria could be detected on cover-glass preparations in the blood or liver of either bird.

Both rabbits likewise succumbed, one four and the other five days after inoculation. The autopsies point out the radical differences between the hog-cholera bacterium and the coccus under consideration. Before death both animals lay on their sides, breathing slowly. In the one which died first (which had received the smaller dose) the inoculated thigh was enlarged and drawn up to the body, the fascia covering the muscles of the thigh and the contiguous abdominal wall were thickened into whitish opaque sheets; a small area of the thigh muscles was whitish, necrosed. In the abdominal cavity strings and flakes of coagulated fibrin in various parts, together with the reddened appearance of the peritoneum, indicated a severe peritonitis; the liver was dark, blood flowing freely on section; spleen scarcely enlarged. Beneath the serosa of large intestine a few patches of extravasation; kidneys deeply reddened to the tip of the papilla; lungs normal. The microbe was very abundant in the local infiltration, the peritoneal exudate, in the parenchyma of spleen, liver, and kidneys, as well as in blood from the heart. In these cover-glass preparations involution forms were very common. Liquid cultures from blood of the heart and the peritoneal exudate contained the microbe as it usually appears in liquids. Tube cultures in gelatine from the blood, peritonal exudate, and liver contained very many colonies, growing in a somewhat characteristic manner, to be described later on.

In the other rabbit the local effect was equally extensive, and there was a more marked grayish discoloration of the thigh and contiguous abdominal muscles. Peritonitis less marked; no coagula present. The bacteria not so numerous in the organs, but very abundant in the peritoneal cavity. Liquid cultures from the latter and from blood were pure. Gelatine tubes, cultures from the liver and spleen, contained many colonies.

Rabbits, mice, and pigeons were thus shown susceptible when inoculated with the quantities above mentioned. Two rabbits were at the same time inoculated with large quantities of two other microbes obtained from spleens. Both remained unaffected. In one a small circumscribed abscess could be seen through the skin.

Of the two pigs inoculated (Nos. 330 and 331), No. 330, which had received the larger dose (5^{cc}) died in nine days, after exhibiting the same symptoms as those manifested by the two former cases—debility, loss of appetite, inflamed eyes. In this animal there was a similar condition of the liver, together with a deep yellow staining of the connective and adipose tissue generally. Cultures negative. No. 331 died thirty-five days after inoculation. In this animal there was a less pronounced pathological change in the liver. Icterus present. No cultures were made.

In order to confirm and extend the preceding inoculation experiments a second series was planned in the same way. A beef infusion peptone culture, which had been derived from a single colony of the microbe on a gelatine plate and was twenty-four hours old, was used to inoculate of mice, pigeons, fowls, and white rats 2 each, 1 guinea-pig, and rabbit. The mice, which received $\frac{1}{12}^{cc}$ beneath the skin of the back, died in two and six days respectively. In the first one the spleen and blood were crowded with bacteria, and a liquid culture from the blood proved pure. From the second mouse no cultures were made; bacteria few or absent from the organs. Of the 2 pigeons, 1 inoculated with $\frac{1}{2}^{cc}$ was dead next day. At the place of inoculation in the pectoral the muscular tissue was whitish, parboiled for a depth of one-fourth to one-half inch; cultures from blood and liver sterile. The other pigeon, which received $\frac{1}{4}^{cc}$, survived. The white rats, receiving respectively $\frac{1}{8}^{cc}$ and $\frac{1}{4}^{cc}$ subcutaneously in the thigh, did not prove susceptible. The rabbit, which received $\frac{1}{8}^{cc}$ in the same place, died in three days, after showing symptoms like those in the preceding experiment. Locally the lesions were the same; thickening of the fascia more pronounced; lardaceous appearance of the surface of the muscular tissue; punctiform extravasations both on abdomen and on thigh as far as symphysis pubis. In the abdominal cavity the serous surface of the entire intestine appeared as if sprayed with blood, the extravasation being beneath the serosa and not visible from the mucous surface. Small intestine but faintly reddened; only a few delicate fibrils of exudation as yet visible; a few extravasations on capsule of kidney, which is deeply reddened throughout; spleen and lungs normal; liver invaded by *coccidium oviforme*. Cover-glass preparations of spleen, liver, and peritoneum contain the microbes in abundance; in the peritoneal exudate they seem as numerous as in a liquid culture. Cultures both in beef infusion and in gelatine from the blood and peritoneal fluid were pure.

The guinea-pig, which had received into the thigh a rather large dose, $\frac{1}{4}^{cc}$, succumbed on the sixth day. At the point of inoculation there is but a slight infiltration and thickening of the subcutaneous connective tissue. In the abdomen, both spleen and liver somewhat enlarged. Covering these a thin, translucent, gelatinous layer, easily scraped away, and particularly well marked on the liver. Lungs deeply congested, not collapsed, but showing the impression of the ribs. The pleura covered with a similar exudate. The internal organs contained scarcely any bacteria, but cover-glasses touched to the surface of lungs and liver showed the exudate, consisting chiefly of leucocytes, to contain large numbers of the injected bacteria. Gelatine cultures of blood and from the liver, a liquid culture from the blood, were pure. A liquid culture from the peritoneal surface of spleen contained also a motile bacillus. The contact of this organ with the very thin-walled large intestine may explain the contamination.

Of two fowls inoculated beneath the skin of the pectoral with $\frac{1}{2}^{cc}$ and 1^{cc}, respectively, the one which received the smaller dose died in five days. In this bird the local lesion was very extensive. On removing the thickened, discolored skin the large pectoral was parboiled in appearance throughout half its mass; the remainder of the muscle studded with small extravasations. The pathological changes involved also the smaller pectoral in points and patches, extending through one of

the fenestra of the sternum to the membrane surrounding the coils of intestine. The serum between the two muscles crowded with the injected bacteria. The mucosa of the intestine below the duodenal portion, including the cæca and the rectum, was very much inflamed. The cæca and the cloacal portion of rectum of a very dark red. There were also occasional hemorrhages beneath the mucosa. The bacteria seem to be confined to the local lesion, for cultures from the blood and liver remained sterile. The second fowl remained ill, sitting quietly and not moving unless disturbed. It was killed nine days after inoculation. The local lesion presented the appearance of a more advanced degeneration, but was more circumscribed, and limited in its depth to the larger pectoral. The intestines and other organs were free from inflammation. Cultures from this bird remained sterile.

In order to determine whether there would be any difference in the mortality or the lesions, another mode of inoculation was resorted to. Instead of employing liquid cultures and injecting into the subcutaneous tissue with the hypodermic syringe, a gelatine culture nine days old was used and the inoculation made as follows: In three mice an incision was made through the skin at the root of the tail, and into the subcutis through this incision a loop of the gelatine culture, consisting of a mixture of gelatine and microbes, was introduced. With the same amount two guinea-pigs were inoculated beneath the skin of the abdomen, two pigeons and one fowl beneath the skin covering one of the pectorals, and one rabbit on the inner surface of the ear, near the tip, by puncturing the skin with the point of a lancet and inserting the mass into wound thus made. Of these animals the two guinea-pigs, the rabbit, and two mice died. The pigeons and fowl remained unaffected.

The mice died three and four days after inoculation respectively. One guinea-pig died in five days. The subcutis of the ventral surface of body from neck to pubis was infiltrated with a sero-sanguineous effusion and thickened, the skin itself infiltrated. There was but little change in the internal organs excepting the liver, which was pale and very friable. No exudate indicative of peritonitis, although a cover-glass touched to the surface of the liver contained very many bacteria, which were few in number in liver tissue and blood from the heart. The second guinea-pig died on the eighth day with the same but less extensive local lesions, parenchymatous degeneration of liver and spleen. The rabbit's ear had a deep red blush on the day after inoculation; enlarged slightly and drooping backward. There were no marked symptoms of disease at any time. The animal died on the ninth day. There was an extensive inflammatory infiltration of the subcutaneous tissue and fascia over the sides of head, extending to the top, involving the ventral aspect of neck and extending to shoulders laterally. The subjacent muscular tissue was considerably ecchymosed. Peritoneal exudate absent. Degeneration of liver and spleen. Bacteria numerous in the local infiltration, very few in blood and organs. A liquid culture from heart's blood was found pure.

These results place fowls and pigeons upon the border line of susceptibility; that is, these animals may be destroyed by large doses, but are not affected by small ones. They also put rabbits, guinea-pigs, and mice among the susceptible animals, the first named being the most susceptible. In every case the inoculation seems to produce local lesions, the extent and severity of which seem to stand in an inverse relation to the number of bacteria found in the blood and the internal organs, and in a direct relation to the duration of the disease.

The foregoing inoculations were made from cultures derived from the pleural exudate of pig No. 2 (Sodorus, Ill.). The same germ was isolated from the spleen and blood of the same animal.

Three tubes of gelatine, into which bits of spleen had been put, began to liquefy. (It will be remembered that the spleen was enormously enlarged and softened.) One of these contained only a large bacillus, another the same bacillus and a microbe resembling the one under consideration. By means of plate cultures these were separated and a pure culture of this microbe obtained. By introducing beneath the skin of two mice bits of the spleen containing the two forms a pure culture of the same microbe was obtained from one of the mice which died three days after inoculation. Two mice, inoculated with bits of spleen from the culture containing the liquefying bacillus only, remained unaffected. From a vacuum tube of blood taken directly from the heart of the same animal pure cultures of the same microbe were obtained.

From pig No. 1 (Sodorus) two pipettes were filled with blood, obtained with every precaution directly from the heart. One of these tubes, opened three weeks later, was used to inoculate a liquid culture, which proved, when tested on gelatine plates, a pure culture of

the same microbe obtained from the pleura, the spleen, and the blood of pig No. 2 of the same herd. In the other tube the bacterium of hog-cholera was found. It will be remembered that pig No. 1 had in addition to the ulcerations of the cæcum and colon, partial hepatization of both lungs, while No. 2 had merely the lung lesions. About a month later a liquid culture, made from a gelatine-tube culture of this blood, was used to inoculate a rabbit, only $\frac{1}{24}^{cc}$ being injected subcutaneously into the thigh. The animal was found dead on the third day. The lesions were nearly identical with those observed previously after inoculation with this microbe—local thickening of the fascia, hemorrhagic markings of the muscular tissue, with superficial degeneration at the point of inoculation, ecchymoses on the contiguous abdominal walls, peritonitis indicated by a few stringy deposits on liver, as well as more than the normal quantity of serum. Cover-glass preparations of the spleen and liver revealed a large number of the injected cocci, which, stained in alkaline methylene blue, showed the polar stain very clearly. A cover-glass touched to the serous surface of the large intestine contained immense numbers of the same germ. Gelatine tube cultures of liver and heart's blood grew in the characteristic manner. From the blood culture a second rabbit was inoculated, as follows: The hair was clipped from the inner aspect of the thigh, which was washed with .1 per cent. solution of mercuric chloride. With a flamed lancet a little pocket was formed beneath the skin, into which a small quantity from the gelatine culture was introduced on a platinum loop. The animal sat quietly in the coop, eating but little, and breathing slowly for some days before death, which occurred ten days after inoculation.

Slight enlargement of the inoculated thigh. Subcutaneous tissue over the inner and caudal aspects of the thigh, on the abdomen beyond umbilicus, greatly thickened by inflammatory infiltration, which is of a soft, pasty consistency, grayish white. It is closely adherent to skin, but not to muscular tissue on abdomen, from which it may be easily removed. The muscular tissue beneath is dotted with punctiform extravasations. On the caudal aspect of the thigh the infiltration is closely adherent to muscular tissue as far as the pubis, involving the superficial muscular fibers, which are whitish, softened; the groin stained with a frothy, blood-stained serum; the superficial lymphatic gland on the same side enlarged to size of a horse-chestnut; on section whitish, lardaceous; the lobules of the gland appearing as pale red masses imbedded in it. The serosa of intestines and the liver coated with a glairy, translucent, grayish deposit, which may be drawn out into threads and peeled from the liver in a thin layer. This exudate contains very few cells, but immense numbers of bacteria, evidently in a state of active multiplication, as they are quite small, resembling oval cocci, and staining uniformly. Parenchyma of liver uniformly dark brownish; bile very dark greenish; spleen not enlarged; lungs normal; right heart filled with a translucent gelatinous clot; left, with dark liquid blood; mucosa of stomach, which contains considerable food, coated with a tenacious mucus; circumscribed hemorrhagic spots scattered over the right half of the stomach; very few bacteria in the parenchyma of spleen and liver.

In this case ten days elapsed between inoculation and death. The local lesion was very extensive, the peritonitis advanced. According to previous experience the difference between this and the preceding case was due entirely to the mode of inoculation. There is also another difference worthy of note. In the preceding rabbit the bacteria showed very beautifully the stain at the ends of the short rod; in this one they did not show it clearly at all.

This microbe was therefore present in the pleural cavity, in blood from the heart, and in the spleen of one pig, and in the blood of another. It is highly probable, judging from the microscopic exam-

ination of the diseased lungs, that if circumstances had permitted a thorough examination of the lung tissue itself by means of cultures and inoculation experiments, the same results would have been obtained. This, however, was quite impossible under the circumstances.*

This microbe, from Geneseo, Ill., also found associated with completely hepatized lungs, was without doubt the same as the one just described, when we take into consideration microscopical characters and those brought out by culture and inoculation. This microbe had not yet been tried upon fowls. In order to confirm still further the results already given the following experiment was tried:

October 30, two pigs and two fowls were inoculated with the microbe from Geneseo, and an equal number with that from Sodorus, Ill. The pigs received subcutaneously each 5^{cc} of a beef-infusion peptone culture. Of the four only two died. One of these had been inoculated with the microbe from Sodorus. On the third day both eyes were discharging, the animal looking unthrifty and becoming weak and thin. It died on the eighth day. In brief the lesions were as follows: Fat and connective tissue in general yellowish. Both ventricles of heart filled with large washed clots and semi-coagulated blood. Liver very firm, of a dirty red-lead color. On cutting into it a gritty sensation is transmitted to the hand. Venous stasis of the abdominal vessels. Other organs and intestinal tract normal. Cultures failed to detect the microbe in the spleen, liver, and blood.

No. 363, inoculated with 5^{cc} from a culture of the microbe obtained from Geneseo, Ill., showed inflammation of the eyes a few days after, which disappeared in a week. At the same time the animal looked unthrifty. It had apparently recovered two weeks after inoculation, when it again became unthrifty and weak. The abdomen became enlarged and it was unable to rise. Found dead December 27, nearly two months after inoculation. At each point of inoculation on the thigh an encysted mass was found in the subcutaneous tissue as large as a marble. The contents were softening and inclosed by a fibrous wall. Lungs hypostatic. Pulmonary vessels and right heart filled with a firm clot. Liver very much contracted, especially the lobes on the right, and streaked with depressed lines and furrows. The peritoneal covering on the cephalic aspect was very much thickened, in some places uniformly, in others in a mesh-work corresponding to the interlobular tissue. The acini of this side were very small. On the caudal aspect they were in some places very large and bulging. On section this transition from large below to small above could be easily traced. Gall bladder filled with a thick prune-juice-colored bile. Inflammatory adhesion between rectum and cæcum. The mucous membrane of the large intestine of a dull red color, probably due to a passive congestion. No ulceration anywhere to be seen. The intestine itself was very much distended with dry, half-digested feces of a yellowish hue. Four liquid cultures made from blood of heart remained clear.

This case is interesting in that the inoculation caused a cirrhosis of the liver, which became indirectly fatal by destroying in great part the normal functions of this organ.

Both fowls inoculated with the microbe from Sodorus died. One of them, which received $\frac{1}{2}^{cc}$ of the liquid cultures into the pectoral muscle, had a temperature of $110\frac{3}{4}°$ F. next day. It began to grow weak rapidly, the temperature remaining high, and it died on the ninth day. The only lesion was the parboiled condition of the pectoral muscles. No growth in cultures from the liver. The other fowl, which had received but $\frac{1}{8}^{cc}$ of the culture, lingered in the same condition, becoming very emaciated. It died on the seventeenth day. The inoculated pectoral muscle very pale and infiltrated with serum. Yellowish necrotic masses embedded in it. Extravasations beneath serosa of duodenum, also beneath corresponding mucosa. The mesentery streaked with petechiæ near the vessels. Terminal portion of rectum dilated, filled with yellowish semi-liquid matter; mucosa of this region intensely dark red.

One of the fowls inoculated with $\frac{1}{2}^{cc}$ from a culture of the microbe from Geneseo died on the fourth day. Extensive serous infiltration and tumefaction of the inoculated pectoral, which is firm, whitish, parboiled in appearance; mesentery adjacent to pectorals slightly inflamed; slight congestion of duodenum.

This case demonstrates a similarity of pathogenic power of the two cultures both upon pigs and fowls. In these cases the local infiltra-

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*Very recent investigations of the disease in the District of Columbia have confirmed these statements. **The pathogenic bacteria are limited almost exclusively to the diseased lungs.**

tion contained the microbe in abundance, but cultures from the blood and liver remained sterile. It seems that it has not the power to multiply in the internal organs, though producing exceedingly severe local lesions sufficient to cause death. The lesions which the subcutaneous injection of the microbe produces in pigs were so uniform and yet so peculiar, that it seemed necessary to add a few more experiments to those already made.

November 18, two pigs (Nos. 374 and 375) received hypodermically 5^{cc} (one-half into each thigh) of a beef-infusion peptone culture two days old, derived from a gelatine culture (rabbit) about one month old. Three pigs were placed with these to determine whether the disease was infectious. In both animals two days after inoculation the sclerotic became deeply reddened. This congestion was followed by discharge, which gummed the lids together for a part of the time. In about a week these symptoms gave way and the eyes became jaundiced. The eyes of the three check pigs were not affected. No. 375 died November 25, one week after inoculation. The subcutaneous connective tissue of a deep yellow color. The points of inoculation occupied by cysts filled with a blood-stained serum. Blood black, partially coagulated. Hypostatic congestion of lungs. Purplish spots beneath pleura and in parenchyma; some lung worms present. Liver very pale, bloodless, very tough. The sclerosis general and the contraction of the connective tissue has made the caudal aspect very concave. Removed from the body it resembles india-rubber, as it retains the same form in whatever position it is laid. Gritty sensation when cut. The gall bladder filled with semi-liquid, dark brown bile, resembling plum juice, surrounding a mass of putty-like consistency and of the same color. The papillar opening of the common duct into the duodenum contained a plug of gelatinous mucus, and when the duct was slit open it contained mucus only. The walls were not even bile-stained; the secretion of bile had ceased some time past. When the liver was cut the section was of a dirty reddish-yellow color throughout; no blood flowed from the vessels; when scraped the cellular elements of the acini came away readily, leaving the tough interlobular tissue *in situ* as a honey-combed mass.

Sections hardened in alcohol and stained in alum-carmine showed a large amount of connective tissue as compared with the normal liver. This increase was general. In the parenchyma of the lobules there were circumscribed areas in which the protoplasm of the cells stained very feebly, while the nuclei were either shriveled or else replaced by a group of granules. The characteristic trabecular structure in these areas was more or less destroyed. Almost every lobule examined contained these altered regions, which were situated as a rule near the periphery.

There was a very marked venous stasis of the portal circulation, characterized by an overdistension of the vessels, bringing even the smallest into view. The vasa recta of kidneys very prominent, giving the pyramids a bright red appearance. Serum in the abdominal cavity of a deep yellow. This yellow tinge is present in the fat around the base of the heart. The urine deep yellow, the mucosa of bladder stained with the same color. The urine readily gives, with Gmelin's test, the colors characteristic of the bile pigments. The intestinal tract normal throughout, save what changes arose from the general stasis of the portal circulation. The stomach empty and coated with a viscid mucus.

The injected microbe which without doubt caused these lesions

could not be found. Three tubes of culture liquid were inoculated each with three to four drops of the blood from the heart. They remained sterile. Bits of spleen and liver about $\frac{1}{2}^{cm}$ cube were dropped into tubes. They also remained sterile.

No. 374 lived longer, became very weak and stupid, and finally was unable to rise. Eleven days after inoculation it died. At one of the points of inoculation there was a firm, tough tumor. The lesions were very similar to those just given, but less pronounced. There was but slight icterus of the connective tissue. Serum in pericardial cavity and fat about heart stained yellow. Urine gives very easily the reaction for bile pigments. Lungs hypostatic. Both sides of heart filled with black coagula. Liver in the same condition as that of No. 375. Gall bladder as above. The common duct was patent and still bile-stained. Venous stasis of portal system but slightly marked. Intestinal tract normal. Four liquid cultures of blood from the heart remain sterile. Into one a large coagulum had been dropped. Two pieces of liver and two from the spleen fail to induce any bacterial growth whatever in the liquids into which they are dropped. The check animals remained well for a month after.

The uniform success in producing most severe cases of hog-cholera by feeding pure liquid cultures of hog-cholera bacteria to pigs which had been deprived of food for 24 to 36 hours led to the inference that the same result might be expected from the microbe of pneumonia, provided it was at all capable of being infectious by way of the intestinal tract.

December 19.—Two pigs (385, 386) were deprived of food for 32 hours. No. 385 then received a liter of beef broth containing 10 grams of sodium carbonate to increase the alkalinity of the stomach. Each was thereupon fed with 250^{cc}. of a culture of the pneumonia microbe in simple beef infusion six days old. This dose was mixed with beef broth to make one liter. Up to the time of writing (January 27) not the slightest disturbance in health has been manifest. Three pigs fed about the same time and in the same way with cultures of hog-cholera bacteria all succumbed, with very severe lesions of the intestinal tract. (Page 614.)

This microbe had thus produced, when injected beneath the skin in quantities not less than 5^{cc} of culture liquid (beef infusion with 1 per cent. peptone neutralized), an acute cirrhosis of the liver in seven out of ten pigs. The pathological changes in most cases were so severe as to check the formation of bile entirely. We must provisionally accept the theory that the injected microbes exert their pathogenic power chiefly upon the liver. Perhaps the germs are deposited there by the blood current and cause an acute inflammatory hyperplasia of the interlobular tissue. In contracting, the portal vessels and bile ducts are compressed so as to become impervious. This produces a venous congestion of the abdominal organs, which pour their blood into the portal vein, and a generalized icterus, caused perhaps by the retention of the bile elements in the blood, as well as their reabsorption from the liver. Meanwhile the bacteria themselves are destroyed in the tissues, so that at the death of the animal none can be found even by means of the most delicate methods of cultivation.

That the three pigs which did not succumb to the inoculation were not affected is not warranted, as the following experiment shows: A pig was inoculated by injecting into the trachea a culture of this microbe. The pig remained well for several weeks, when it was killed for examination. At the autopsy it was found that owing to the thick layer of fat in the neck the injection did not enter the trachea. A tumor almost as large as a hen's egg had formed by the side of the

trachea. Its center was already softened. The organs were apparently normal with the exception of the liver, which is extremely pale and bloodless, showing signs of cirrhosis.

GENERAL CHARACTERS OF THE MICROBE CAUSING PNEUMONIA IN SWINE.

In cover-glass preparations from the organs of animals which have died from inoculation, and of which the rabbit presents the best advantages for study, the microbes appear as oval bodies, measuring about 1 to 1.2 micromillimeters in length and .6 to .8 micromillimeter in breadth. When stained by some aniline, such as an aqueous solution of methyl violet or an alkaline solution of methylene blue, their appearance is very much like that of the microbes of rabbit septicæmia. The two extremities of the longer axis are deeply stained. Between these colored masses a transverse band remains transparent, without any color. This unstained portion may vary between one-fourth and one-half of the entire optical area of the oval. It is limited on either side by a very delicate, stained line (Plate III, Fig. 2; Plate IX, Fig. 1). It is probable that this appearance arises during the elongation of the coccus preparatory to a transverse division into two, and that the width of this unstained area depends upon the stage of the process. Among the cocci there may be seen in cover-glass preparations of liquid cultures rodlike forms as broad as the cocci, imperfectly segmented, and attaining in a few cases a length of 15 to 20 micromillimeters. These filaments must be regarded as involution forms of the cocci, due to a want of power of division; for such a form is frequently of varying width and the extremities irregularly tapering; moreover, the cultures containing them are invariably found pure when tested on gelatine plates. This abnormal growth is not confined to cultures. It is found in cover-glass preparations made directly from the tissues of animals which have succumbed to inoculation with pure cultures. They are common in mice and rabbits. In the former animals they assume a bacillar form occasionally, in rabbits a form staining very irregularly and resembling swollen diplococci. In the earlier experiments with this microbe these abnormal appearances were very puzzling. Inoculation of liquids with these bacteria gave invariably the same form. Gelatine tube cultures and the colonies on plates always proved the same. It became necessary to conclude from these results that, although fatal to these animals to a very high degree, this particular coccus does not find the best conditions for multiplication in these animals; or else it may be found that some slight variations in the manipulation of cover-glass preparations, a too rapid drying or a greater heat applied to the dried film, may cause changes in the microscopical appearances of the stained germ. Whatever the reason may be, the striking fact remains that in some rabbits the bacteria on cover-glass preparations are regular and uniformly stained at both extremities; in others they are irregular in outline and the staining is not characteristic.

If a neutralized beef infusion with 1 per cent. peptone be inoculated with this microbe a faint opalescence pervades the entire fluid on the following day. There is no membrane present at this stage, nor after several weeks. A pure liquid culture of this microbe is easily distinguishable from that of the hog-cholera bacterium. The latter is more opaque, and when the tube is shaken rolling clouds are formed. This is not seen in the faint opalescent liquid of the

former. It will also be remembered that after one or two weeks a ring of deposit forms about the tube at the surface of the liquid in the culture of the hog-cholera bacterium. In a few cultures an incomplete surface membrane may also appear. It multiplies more abundantly, therefore, in this medium than the more delicate microbe under consideration.

If a drop from a culture one day old be examined with a $\frac{1}{18}$ homogeneous objective *no spontaneous movements* can be observed. When dried and stained in an aqueous solution of methyl violet or other aniline, the microbes are best studied, as regards their form, at the circumference of the dried film, where they have been drawn together in large numbers by the slow drying of the drop. The microbe appears in the form of an oval coccus, about .6 to .7 micromillimeter long and .4 micromillimeter broad. The small size makes the exact measurement very difficult. Besides these there are smaller and larger forms measuring 1 micromillimeter in length. The great majority of forms correspond with the dimensions first given. Those around the border of the dried film usually show the characteristic stain at the extremities with the unstained band between. The remainder are usually so small that this cannot be made out, or else they are in that stage of growth when division has not yet begun, and are uniformly colored.

If a minute portion from the organs of a rabbit, or from a culture of this microbe, be shaken up with nutrient gelatine, barely liquefied by a gentle heat, and the mixture poured on plates, the colonies will become visible to the unaided eye in about two days, provided the temperature does not fall below 70° F. They are round, with pale homogeneous disk, when examined with transmitted light. Their growth is slow, and at the end of a week they vary in diameter from $\frac{1}{4}^{mm}$ to $\frac{1}{2}^{mm}$. Their appearance at this age is peculiar (Plate IV, Fig. 5). Each colony is provided with a border of varying width, usually not exceeding one-fourth the radius of the colony. This border is paler than the central portion, and sharply separated from it by a circular line, sometimes slightly eccentric, as in the illustration. The central disk is usually somewhat granular at this stage. The colonies when growing on the surface of the layer of gelatine spread quite rapidly, and soon are four or five times the size of the deep colonies. The margin of the more or less circular patch is very thin and sharp, and slightly wavy. This microbe *does not liquefy the gelatine* at any time of its growth.

In tubes containing nutrient gelatine the microbes carried by the needle into the depths of the gelatine develop into spherical colonies which do not become larger than $\frac{1}{2}^{mm}$ in diameter (Plate IV, Figs. 1, 2). The surface growth is quite vigorous. It spreads as a pearly white circular patch in all directions from the point of inoculation. This patch is not convex, but uniformly thick, usually with a wavy or scalloped border (Plate V, Fig. 1, *b*). The growth is very slow as a rule, varying with the temperature of the room. It requires several weeks for a disk a few millimeters in diameter to form, and from one to two months for one 5^{mm} to 10^{mm}. When viewed obliquely very faint concentric markings may usually be observed on this pearly growth. There are some slight differences between the tube cultures of the microbe of genuine hog-cholera and this organism, which are entirely expressed in the surface growth (Plate V, fig. 1, *a*, *b*). In the second annual report the tube culture of the bacterium of hog-cholera was figured as having very minute deep colonies and scarcely

any surface growth. Later observations showed that if a more alkaline nutrient gelatine be used the growth is far more vigorous; the deep colonies are much larger and the surface growth abundant (Plate VI, Figs. 4, 5). It presents either as a compact convex pearly disk or button, or as a very irregular flat patch, sending out ragged prolongations over the surface of the gelatine.

This microbe grows upon blood serum from the cow. On the surface the growth is very thin, scarcely visible. In the needle track a dense opaque mass forms. On the condensation liquid in the bottom of the tube a whitish, brittle membrane is present. Repeated efforts to induce growth on potato have thus far failed. In milk its multiplication is not very great when compared with the other microbes. It is capable to a certain extent of multiplying in tubes from which the air has been exhausted and in which the ordinary saprophytes remain dormant. When exposed to a temperature of 58° C. for fifteen minutes it is invariably destroyed. This is true of the bacteria taken directly from the animal as well as of those in liquid cultures. This microbe is easily killed by drying, three days being sufficient, whether it is taken from cultures or from the tissues of the dead animal.

Upon sterilized cover-glasses a drop from a liquid culture two days old is allowed to dry under a plugged funnel. On the third day a tube of beef infusion, into which one of these cover-glasses had been dropped, remained clear. On the sixth, seventh, and ninth days tubes were inoculated in the same way, which also remained clear.

Exudate from the peritoneal surface of the liver of a rabbit which died from inoculation was dried on cover-glasses and tested in the same way. The exudate contained immense numbers of microbes. One tube inoculated after four hours' drying, two after one day, and two after two days became opalescent and were found pure cultures. Two inoculated on the third, fourth, and fifth day remained clear.

The multiplication in ordinary drinking water was tested as described for the hog-cholera bacteria. The latter, very hardy, as the experiments showed, remained alive in large numbers for months. The microbes under consideration showed themselves almost incapable of living and multiplying in such water. In fact, it is very probable that many are destroyed in being transferred into it from nutrient media.

On November 20 a tube containing sterilized Potomac drinking water was inoculated from a culture two days old. A plate culture immediately prepared to determine the number of germs transferred was lost by accident. Judging from preceding experiments, there could not have been less than 50,000 in 1^{cc} of the water. Plate cultures containing .1^{cc} of water were made two and three days after inoculation. Nothing grew upon either plate. On the sixth day a tube of beef-infusion peptone was inoculated from the water. The liquid remained clear.

On November 27 a tube containing sterilized Potomac drinking water was inoculated from a liquid culture of the microbe twenty-four hours old. A plate culture made immediately after the inoculation showed two days later that each cubic centimeter of the water contained after inoculation about 140,000 microbes. After standing for two days at a temperature of 22° to 25° C. a plate culture made with about $\frac{1}{300}$^{cc}, which should have contained at least 500 colonies, showed none whatever. December 6, nine days after inoculation, $\frac{1}{8}$^{cc} was added to a tube of beef infusion peptone. On the following day this tube was turbid and contained the microbe only. Hence a few individuals were still alive on the ninth day. A plate culture was made from the same water twenty-four days later by adding $\frac{1}{2}$^{cc} to the gelatine before pouring it upon the plate. No colonies grew. Finally a tube of nutrient liquid, to which $\frac{1}{4}$^{cc} was added on the twenty-seventh day, remained clear. Hence all the microbes were practically dead before a month had passed, and the great majority perished, without doubt, a few days after being mixed with the water.

The appearances and morphological differences of the microbes discovered in hog-cholera and in the infectious pneumonia which we now call swine-plague, are illustrated by the photo-micrographs reproduced in Plates VII, VIII, and IX. The microbe of hog-cholera is seen in Plate VII, Fig. 1, as it appears in the tissues of the body. Most of the germs in this case are sufficiently elongated to be classed as bacilli. In cultures where more rapid multiplication occurs the microbe is shorter and assumes an oval form (Plate VII, Fig. 2). The microbe from the Nebrasba outbreak of hog-cholera, referred to above, maintained a distinctly rod-like form, however, even in liquid cultures (Plate VIII, Fig. 1). The micrococcus of swine-plague, which is plainly oval in the tissues and in the blood, as shown in Plate IX, Figs. 1, 2, becomes very nearly or quite spherical in liquid cultures (Plate VIII, Fig. 2). This is also very nearly the form seen in gelatine cultures.

The following comparative table sets forth briefly the differences between the bacterium of hog-cholera and the microbe which has been found associated with pneumonia in pigs and described in the preceding pages:

HOG-CHOLERA BACTERIUM.	MICROBE OF PNEUMONIA.
Morphological and biological properties.	*Morphological and biological properties.*
1. Ovals varying in length from 1.2^{mm} to 1.8^{mm}.	1. Ovals varying in length from $.8^{mm}$ to 1.2^{mm}. (In both species the size is very variable, according to the stage of growth and division and the culture medium.) This microbe is in general much smaller than the bacterium of swine-plague.
2. Stains around periphery, with a slight increase in the width of the stained border at the extremities; observed chiefly in the tissues of animals. In cultures may stain entirely.	2. Stains in process of division at the two extremities only.
3. *Motile* in liquids.	3. *Non-motile* in liquids.
4. Grows actively on potato.	4. Growth on potato fails. Growth in nutrient liquids more feeble; on gelatine almost as vigorous.
5. Resists drying for one to two months.	5. Resists drying only a few days.
6. Multiplies for a time in drinking water, and remains alive at least four months.	6. Does not multiply in drinking water, and is entirely destroyed in a few weeks.
Pathogenic effects.	*Pathogenic effects.*
1. In small susceptible animals subcutaneous inoculation causes but slight local reaction.	1. Local reaction usually very severe and extensive.
2. In mice it always produces a disease lasting from eight to sixteen days; spleen enormously enlarged; liver enlarged and containing numerous foci of coagulation necrosis.	2. Mice destroyed, but not invariably, in two to six days. No characteristic lesions.
3. In rabbits the disease produced by inoculation of small quanties of culture liquid into thigh lasts from six to nine days. Great enlargement of spleen; enlargement of liver and centers of coagulation necrosis. Local lesion: circumscribed necrosis of muscular tissue. Lungs usually have hemorrhagic foci or more extensive lobular pneumonia.	3. Same mode of inoculation destroys life in from three to six days. Extensive local sero-sanguineous, later purulent infiltration and thickening; plastic peritonitis; spleen not enlarged.

4. Same mode of inoculation destroys guinea-pigs, with a few exceptions. Lesions quite the same as in rabbits. May live fourteen days.	4. Guinea-pigs somewhat more refractory; extensive local lesions as in rabbits; occasionally plastic peritonitis; die in four to six days; spleen not enlarged.
5. Pigeons destroyed by large doses. Bacteria in internal organs.	5. Pigeons also susceptible to large doses. Bacteria absent from internal organs.
6. No fowls destroyed by inoculation.	6. Large doses kill fowls. Very extensive local infiltration and destruction of muscular tissue.
7. Pigs are either not affected by hypodermic injection, or else a severe disease follows, characterized by hemorrhages in all organs. Bacteria present in large numbers in internal organs.	7. Large doses cause acute sclerosis of liver, with icterus. Bacteria absent.
8. Feeding cultures after starving for a day produces extensive necrosis of mucous membrane of large intestine; inflammation and occasional ulceration of stomach and ileum.	8. Feeding cultures produces no effect whatever.

The inoculations apply to subcutaneous injections of small quantities of liquid cultures, in mammals on the inner aspect of the thigh, in birds on the pectoral.

MORE RECENT OUTBREAKS OF INFECTIOUS PNEUMONIA.

Recently specimens were received from an outbreak of infectious pneumonia in Iowa. According to information obtained by Dr. N. H. Paaren in January, 1887, a disease of swine prevailed during the fall and winter of 1885–'86, and during the same period of 1886–'87, which was limited chiefly to the four counties of Worth, Mitchell, Cerro Gordo, and Floyd, along the Shell Rock River. Specimens of lung tissue were obtained from Cerro Gordo County, although the disease was almost extinct at this time (January, 1887).

At Mason City Dr. Paaren examined a number of dead hogs at a soap factory, which had been brought together from different parts of the surrounding country. In these animals the lungs were uniformly diseased, the digestive tract normal or but slightly congested. The liver also was diseased in all examined.

From these observations it would seem that the disease prevalent in Iowa was the infectious pneumonia which has been described in the preceding pages, and not the real hog-cholera. The following experiments tend to confirm these views:

Pieces of lung tissue sent from Cerro Gordo County were partly immersed in a blood-stained liquid which must have exuded from the lungs. The animal was frozen solid when the tissues were removed. Both pieces of lung tissue had a faint, not putrescent odor. They were of a red flesh color. The tissue seemed completely airless. Cover-glass preparations showed the infiltration to be made up almost exclusively of small round cells, with an occasional epitheloid cell amongst them. Careful observation demonstrated the presence of very minute oval bacteria, varying slightly in length. The longest (perhaps not more than 1^{mm}) stained only at the extremities. There were no other bacteria visible to indicate any advanced decomposition. In one of the pieces the knife had been passed through an irregular cavity in the lung substance as large as a marble, lobu-

*Lately a disease of the lungs, probably identical with the infectious pneumonia under discussion, came to our notice in the District of Columbia, from which the same microbe was obtained. A detailed account must be reserved for future publication.

lated, bounded by a membrane, and partly filled with an inspissated substance easily crumbled, and consisting entirely of round cells. There was also marked pleuritis. The pleura of the portions sent was thickened, and a spongy membranous exudate, about $\frac{2}{3}^{mm}$ thick, had formed, which consisted also of small round cells exclusively.

A number of plate cultures were made by shaking up pieces of lung tissue and pleural exudate in gelatine and pouring it on plates. These plates were, as a rule, negative. Inoculations into animals proved more successful, however.

Two mice were inoculated by placing bits of the lung tissue beneath the skin at the root of the tail. One mouse died on the second day. Internal organs unchanged; no local reaction; no bacteria to be seen on cover-glass preparations of spleen and liver.

The second mouse died on the third day, though apparently well the day before. In this animal the spleen was very dark and enlarged; liver also much congested. In these two organs, as well as in the blood from the heart, oval bacteria were present in large quantities. Plate cultures and liquid cultures of blood proved them to be the immotile oval microbe already described.

Two rabbits had been inoculated at the same time by placing a bit of the lung beneath the skin of the thigh on its inner aspect. One of them died in five days. The local reaction, very slight, was limited to a small mass of pus in the subcutaneous tissue. The muscular tissue was not involved. The internal organs were also unchanged, but in all of them the microbe already described was present in immense numbers in the spleen and liver, fewer in heart's blood and kidneys. Gelatine cultures from spleen and liver and two liquid cultures of heart's blood contained only the specific microbe. The second rabbit remained well.

Two mice inoculated subcutaneously with a liquid culture derived from a gelatine tube of the above rabbit died within twenty hours, though each had received but $\frac{1}{6}^{cc}$ of liquid. The spleen and liver crowded with the injected microbe.

From a tube culture in nutrient gelatine a tube of beef infusion was inoculated, and on the following day a rabbit was inoculated hypodermically into the thigh with a few drops, and two pigeons, beneath the skin of the pectoral, with $\frac{1}{2}^{cc}$ to $\frac{3}{4}^{cc}$ from the same culture. In the former bird the needle entered the pectoral muscle. The rabbit was found dead next morning, not longer than eighteen hours after inoculation. At the place of injection a few ecchymoses and distended vessels on the inner surface of the skin. A lymph gland near by deeply reddened. A few threads of fibrinous exudate on coils of intestine. Lungs hypostatic. Immense numbers of bacteria in liver, spleen, and heart's blood, most of them showing the characteristic stain at the ends.

The pigeon which had received $\frac{1}{2}^{cc}$ into the pectoral died in twenty-four hours. In this bird the pectoral was discolored, parboiled for a depth of one-half inch and over an area of about 1 square inch. The subcutis was filled with a reddish serous effusion, the skin slightly thickened. Innumerable bacteria in this local lesion. Fatty degeneration of liver. A small portion of each lung deeply congested. Vessels of duodenum and testes injected. Immense numbers of bacteria in blood from the heart, in the liver and lungs, showing the characteristic stain at the ends very well. The other pigeon was not affected.

The fowls inoculated with $\frac{1}{2}^{cc}$ of a liquid culture of this microbe remained unaffected. Similarly two pigs, which had received each 5^{cc} beneath the skin of the thigh, remained well.

Specimens from the Mason City soap factory were like the first. The lung tissue was enlarged, solidified, and of a pale reddish color. When sections were made into this airless mass the cut surface showed a reddish ground, in which were embedded whitish specks about $\frac{1}{2}$ to 1 micromillimeter in diameter. These protruded slightly, giving the surface a granular appearance. They could be lifted out, and when crushed upon a cover-glass and stained small round and larger epitheloid cells were found to make up the mass. Bacteria of different kinds indicated *post mortem* multiplication.

These lesions were therefore very much like those found in Illinois, and there is no reason to doubt that they were caused by the same agency. In all of the lungs thus far examined from which the same

microbe was obtained the vesicular portion of the lungs was filled with a cellular exudate, partly derived by a desquamation of the alveolar epithelium and partly by an infiltration of cells from the blood.

Two rabbits inoculated by rubbing some of the scrapings from the cut surface of the lung tissue into a wound made on the inner surface of the ear remained well. One mouse inoculated as above died next day. No bacteria in the organs. Blood cultures remain sterile. A third rabbit was inoculated by placing a bit of lung substance beneath the skin of the thigh and closing the incision with a stitch. The animal remained well.

No positive results were thus obtained from this specimen. The source of the animal, the time of death not being known, it is not at all improbable that this specific microbe may perish in the animal body a certain time after death through frost and other agencies. It is not, moreover, to be denied that only certain portions of the lung tissue are, at a given time, the seat of active bacterial growth. These portions may not have been sent to us.

It seems that this hitherto unrecognized disease in swine is far more prevalent in the Western States than was at first supposed. It therefore becomes necessary to inquire more carefully into the distribution of these two maladies and to determine whether they do not frequently exist in the same localities.

The microbe from Iowa outbreaks showed a greater virulence, as a few drops of culture fluid were sufficient to destroy mice and rabbits in less than twenty-four hours. Whether such differences are sufficient to account for the varying severity of the disease in different localities remains to be determined by more extended observation. The fact that the subcutaneous inoculation of cultures did not affect two pigs may be due to a want of power to develop in the internal organs. This is virtually the case in the disease, as it appears naturally among swine. Though the lungs may be extensively diseased, the blood, spleen, and other internal organs are practically free from bacteria. The disease seems to be caused by inhaling or aspirating the specific bacteria, which exert their destructive effect in the alveoli and smaller bronchi, and do not in reality enter the blood of the affected animal. The final test will rest upon the possibility of producing the specific lung disease by means of inhalation experiments which are now being carried on.

RECENT FOREIGN INVESTIGATIONS IN INFECTIOUS SWINE DISEASES.

The investigations by foreign observers during the past year upon infectious diseases of swine, and more especially their causation, have led to some interesting results, which deserve careful consideration. In the Second Annual Report of this Bureau it was pointed out that the disease known in this country as swine-plague, or more commonly as hog-cholera, was wholly different from the disease known on the Continent as *rouget* and *Rothlauf*. Not only are the lesions different, but the micro-organisms producing them wholly unlike in their microscopical and biological features, as well as in their pathogenic effect upon animals. Thus far *rouget* has not been found in this country. The conclusions reached last year, though doubted by those who seemed to consider all infectious or contagious diseases of swine identical, are unshaken. All efforts at practicing preventive inoculation in hog-cholera with virus derived from *rouget* must not only be looked upon as absurd in the light of present knowledge, but as dan-

gerous, inasmuch as a new disease may thus be introduced into our country from abroad.

The important lesson taught by these investigations lies on the surface. Infectious diseases in which the gross pathological effects differ quite constantly in the same species of animals should not be classed as identical until so proved by the most rigorous methods that scientific research possesses.

On page 226 of the Second Annual Report of the Bureau (1885) a brief mention was made of a disease found once by Löffler in Germany, which presented as the most marked lesion an enormous œdema or swelling of the skin of the neck. It is caused by small ovid bacteria, calling to mind by their appearance the organisms of septicæmia in rabbits, especially when in the process of division, although but half as large. Inoculation with these bacteria produced speedy death in rabbits, mice, and guinea-pigs, as well as pigs. Rabbits died within twenty-four hours; mice lived a few hours longer; guinea-pigs died on the second and third day after inoculation. In all animals there was a sero-sanguinolent effusion into the subcutaneous tissue of the entire abdomen, extending to the axilla on the one hand and the inguinal region on the other. Muscular tissue infiltrated with the same reddish effusion. Pigeons, fowls, and rats remained unaffected after the inoculation. One of the three inoculated pigs died on the second day with the following lesions: "Skin of abdomen bluish red. Enormous œdema of the skin. Lungs hypostatic. Mucosa of stomach deeply reddened. Spleen unchanged. Kidneys parenchymatous. Mesenteric glands not swollen."*

More recently this same infectious disease among swine in Germany has been carefully described and studied by Schutz,† and as it has many features in common with the disease which has been separated from hog-cholera in the preceding pages, it deserves a somewhat careful analysis here.

The author first obtained the microbe causing this disease by placing beneath the skin of small animals bits from spleens of pigs which had presented symptoms of *rouget*. The spleens were putrid, but the pathogenic microbe was found alone in the bodies of the inoculated animals,‡ the putrefactive germs not having the power of penetrating beyond the wound in which they are placed. In this way he inoculated 2 mice, 2 guinea-pigs, 1 pigeon, and 1 rabbit. The mice died on the second and third day. The bacteria found in the organs of these mice have the form of ovals, and are easily stained by watery solutions of aniline colors.

When stained with gentian violet they show in their central portions an unstained region surrounded by a layer stained blue. The thickness of this layer is greater at the poles, so that the extremities appear more deeply stained than the sides. When deeply stained they appear uniformly blue. As these organisms stand between micrococoeci and bacilli, they may be called bacteria. They are 1.2^{mm} long and $.4^{mm}$ to $.5^{mm}$ broad. They multiply in the following manner: They become twice as long as broad, show distinctly rounded extremities, and stain like the organisms of rabbit septicæmia and fowl-cholera, so that between the deeply stained ends about one-half or a third of the entire length remains unstained. Careful examination shows, however, that the colored end pieces are connected with each other by a fine line which passes from one to another on each side. The end pieces then separate and the median portion disappears. The former are at first spherical, but very soon

* Arbeiten a. d. kaiserlichen Gesundheitsamte, I, S. 377.
† *Loc. cit.* S. 376.
‡ The bacterium of hog-cholera as found in Nebraska was obtained pure in the same way as described elsewhere in this report (p. 628).

assume an oval form. Hence from every organism two new individuals arise by division, in which by careful staining the uncolored central portion is easily distinguished from the colored periphery. If the process of multiplication is very rapid, as in pigs and rabbits, the organisms do not attain the size given above, but divide before the unstained median piece becomes distinctly visible. Under these circumstances the organisms of the succeeding generations are smaller, only one-half as large as, or even smaller than, those which have resulted from the slow division of the bacteria. The younger generations are frequently extraordinarily small, plainly oval, however, and staining uniformly in gentian violet. * * * They do not execute any spontaneous movements.

This description applies very well to the microbe found by us in pigs with lung disease. It points out the folly of expecting to determine a specific form with the aid of a microscope and an aniline stain only, when we reflect how many different forms of one specific microbe may be met with, according to the rapidity of multiplication, which in turn depends upon the medium in which they grow.

We will continue with the author's statement. The rabbit died on the third day. From the inoculated ear an inflammatory swelling had spread over the entire head and neck, due to an extensive effusion of a turbid liquid into the subcutaneous connective tissue. Enlargement of neighboring lymphatics. Bacteria in the blood and all organs, especially numerous in the subcutaneous effusion. The two guinea-pigs and the pigeons remained well. Gelatine tubes inoculated with this germ show no signs of liquefaction at any time. With a pure culture on gelatine the author inoculated two mice, one rabbit, and three pigeons. The mice died on the first and second day after inoculation respectively. The lesions were as follows: "Slight œdema and hyperæmia of the subcutis. Swelling of the lumbar, inguinal, and mesenteric lymphatic glands. Large intestine filled with feces; spleen considerably enlarged. Parenchymatous inflammation of liver, kidneys, heart, and muscles. Portion of blood coagulated; the remainder coagulates on exposure to air. Bacteria in all the organs."

The rabbit died on the second day after inoculation. Besides local and general lesions already mentioned, there is an implication of the respiratory apparatus (tracheitis and bronchitis hemorrhagica). To these lesions we cannot attribute any specific character whatever. They are very likely due to proximity to the point of inoculation (ear). If the animal had been inoculated in the thigh they might have been absent. The pigeons remained well.

Two pigs were inoculated with beef-infusion peptone culture, obtained from a mouse, each receiving subcutaneously the contents of a Pravaz syringe. On the following day a considerable tumefaction of the thigh appeared. The skin over the swelling was dark red. Both animals were so weak as to be scarcely able to walk. No appetite. Breathing accelerated. One of them died twenty-four hours after inoculation. At the autopsy the following changes were observed: Infiltration of skin, connective and muscular tissue at the point of inoculation, with a red turbid effusion; the skin tough and thickened. About 55^{cc} of turbid yellow liquid in the peritoneal cavity. The other changes given by the author do not point to any specific lesions, and are omitted. The bacteria were found in the exudates and in all the organs, especially numerous in the effusion at the point of inoculation. The other pig died forty-eight hours after inoculation. In this animal the local swelling was also very extensive and severe. Bacteria in all the organs.

The lesions indicated that the bacteria had at first multiplied and exerted their pathogenic effect at the point of inoculation, and thence

had spread over the entire body by way of the blood and lymph channels.

The author calls attention to the great resemblance between the inoculation disease produced by him and by Löffler, and considers the cause the same in both cases.

A pig which had been made insusceptible to *rouget* by vaccination was inoculated with a pure culture of this oval bacterium. It died in two or three days, with extensive local swellings where the inoculation had been made. Bacteria in all the organs; especially numerous in the spleen. This case illustrated the fact that an animal made insusceptible to one disease is not necessarily protected against the virus of another.

Schütz was unable to produce the disease by feeding, as the following shows: After starving a pig for twenty-four hours it was fed with bouillon in which 5 per cent. sodium carbonate was dissolved, and half an hour later with one liter of blood and pieces of flesh from a pig which had succumbed to inoculation. The animal seemed slightly ill for a few days, but recovered.

In continuing these investigations an epidemic came to his notice in which the early symptoms were diarrhœa, sometimes bloody. At the same time the hind legs became stiff, so that the animal lay most of the time. On the sixth and seventh day the back became weak, so that in walking the animals swayed to and fro. They then were scarcely able to reach their food without tumbling over. In a few the ears became red. In all the breathing became labored and hurried. In some twitching and convulsions appeared before death, which occurred on the eighth to the tenth day. Without giving the complete autopsy notes it will suffice to say that there was nothing abnormal in the intestinal tract. The stomach was considerably bile-stained. The lesions were limited to the thoracic cavity. In the pericardial cavity about 36 grams of an opaque reddish fluid. Pericardium and epicardium glued together by small quantities of a warty, stringy, elastic substance:

Both lobes of the left lung, with the exception of the upper border and the four lobes of the right lung, tough and airless (hepatized). In both pleural sacs about 64 grams of an opaque reddish-yellow fluid, mixed with flakes of fibrin. The pleura covering the hepatized portions was rough, dull, clouded. These were in general of a dark grayish red, with interspersed, circumscribed patches of various size and form and grayish-yellow or reddish-yellow in color. * * * On the cut surface of the hepatized portion grayish-red and reddish-yellow areas could be detected, which were sharply marked off from one another. They corresponded to the circumscribed patches on the pleura, were very friable, partly with a pale luster, partly granulated. They occupied larger volumes of lung tissue, or were sprinkled as scattered foci in the grayish-red portions. Their extent was limited by the course of the larger bronchi and blood vessels. The surface of the grayish-red portions was also granulated, of a faint lustre, and clouded. In these there appeared numerous, more resistant, reddish-yellow spots, corresponding to the inner portions of the lobules. They were either isolated or gathered into small groups. The interlobular tissue was filled with a cloudy reddish fluid. In the softer portions of the lung the pleura was smooth, transparent. The cut surface was smooth, shining, and here and there provided with small diffusely dark red spots; resistant. On compression a very fine foam poured out upon the cut surface. The bronchial lymphatics were enlarged, their capsules reddened.

In a second animal the lesions were the same, almost the whole lungs hepatized. These animals had therefore suffered from an acute pleuro-pneumonia, involving the pericardium in the first animal. The yellow regions correspond to necrosed tissue, which, extending to the surface, produces inflammation of the pleura. In cover-glass

preparations of the lung tissue the oval bacteria were found in large numbers. The author infers from the lesions that the bacteria had been aspirated into the finest bronchioles and alveoli and there produced pneumonia. They were also found in the pleural and pericardial cavities. The remaining internal organs contained but few. With portions of the hepatized lungs six mice, five guinea-pigs, two rabbits, two rats, two pigeons, and one fowl were inoculated. The mice and rabbits died in the usual time, and presented lesions already described. Three of the guinea-pigs died on the fourth, fifth, and eighth day respectively. In the two first mentioned the subcutis and muscular tissue at the point of inoculation (abdomen) were infiltrated with a bloody, clouded liquid; in the third animal—an old one—an extensive hemorrhagic and purulent infiltration was present. One of the pigeons died on the third day. The point of inoculation in the subcutis over the pectoral muscle was infiltrated with a fibrinous, purulent mass, containing a few bacteria. These were very scarce in the internal organs. One of the rats died on the seventh day with lesions similar to those of the older guinea-pigs. Very few bacteria in the internal organs. With bits of lung tissue from another pig which succumbed to the same infectious pneumonia the following animals were inoculated: two rabbits, guinea-pigs, pigeons, and fowls, and one rat. The rabbits died in one day, the guinea-pigs in two and five days respectively after inoculation. The two pigeons, which had received comparatively large doses, died in one and two days respectively. The rat and fowls were not affected.

The author also introduced pure cultures directly into the lung tissue of a pig through the chest-wall by means of a hypodermic syringe. The animal died in less than three days. On *post mortem* examination the lungs were necrosed at the point of inoculation; there was severe and extensive pleuritis and pericarditis. Bacteria were very numerous in the affected organs, but very scarce in other organs. In another experiment a pig confined in a box was made to inhale the spray of a liquid culture for several hours on two consecutive days until 500^{cc} had been used up. The animal was killed eleven days later, after having shown marked symptoms of lung disease. The same mortifying pneumonia as that described was found at the autopsy.

Schütz also describes a case in which there was a condition of the lungs, lymphatic glands, and other organs closely resembling tuberculosis. Caseous degeneration of these structures was followed by a gradual loss of strength, leading to death. In this animal there was a caseous degeneration of the various joints of the posterior limb, enlargement and softening of the lymphatics. The oval bacteria were present in large numbers in the caseous contents of the glands. The effect upon the animals when inoculated with this caseous mass was precisely the same as that produced by lung tissue or cultures from former cases.

The disease disappears at the beginning of winter to reappear again in the spring. The losses sustained by one owner from the disease in a single year were very heavy, two hundred pigs having died. It was found in regions a considerable distance apart, which led Schütz to infer that it was a widely distributed disease.

The relation of hog-cholera to this disease.—A careful perusal of this brief synopsis will convince even those who have only observed the gross pathological lesions that are constantly met with in hog-cholera, or who have read the *post mortem* notes as reproduced

and summarized in this and the preceding report, that this new disease described by Schütz has nothing in common with hog-cholera. We regard the description of the disease as given in these reports as the basis for this statement, because the hundreds of cases examined in the laboratory were invariably associated with the same etiological factor—the same bacterium which has been minutely described, and which is at once distinguishable from the microbe described by Schütz. Leaving aside the many differences, a glance into the microscope will show us an actively motile bacterium on the one hand, and on the other a non-motile bacterium. Our investigations have already shown the existence of another bacterial disease in swine, which may even be associated with hog-cholera, in the same herd and in the same animal. From the present standpoint of our information it would be presumably absurd to rely upon *post mortem* examinations in different parts of the country without at the same time making bacteriological investigations, in order to decide the nature of a certain class of symptoms and lesions. We have almost invariably found severe intestinal lesions in hog-cholera, producing ulceration and often complete death of the mucous membrane of the large intestine, involving in the severest cases a similar destruction of the mucous membrane of the ileum. In the autopsy notes given by Schütz the alimentary canal is invariably intact or the slight changes due to general causes. The lesions are limited entirely to the thoracic organs, where the lungs are primarily affected by a "multiple mortifying pneumonia." Thence the disease may involve the pleura and the pericardium.

In hog-cholera, lung lesions are quite secondary and only rarely seen. In the severest hemorrhagic type of the disease we have almost always observed hemorrhagic foci scattered through the lung tissue, but these were no more numerous or more extensive than the extravasations found in most of the other viscera. It is quite easy to believe that such cases surviving the first severe attack may develop a pneumonia by the gradual extension and confluence of the separate foci. In all cases where the causation of such lesions is a matter of doubt bacteriological investigation must now decide.

Relation of infectious pneumonia to this disease.—It is of considerable importance to find out what relation this microbe of the German *Schweineseuche* bears to the one which we have recently found in pigs as the cause of infectious pneumonia. Morphologically they are evidently the same. So far as their growth in culture media and their biological properties have been observed there seem to be no grounds for regarding them as different species. As to their pathogenic properties we find some marked differences. The evidence which has been brought forward in the preceding pages that the microbe there described is the cause of a pneumonia in pigs, which is therefore, from an etiological standpoint, wholly different from hog-cholera, is not yet conclusive, and will require further investigations. Yet the facts there recorded are strongly in favor of the view that we are dealing with a hitherto unrecognized disease. The microbe was obtained from three outbreaks hundreds of miles apart. In the animals examined pneumonia was present. In the one outbreak hog-cholera was also present, as demonstrated by the lesions and the specific bacterium. The presence in the same herd of two diseases, and even in the same animal of two wholly different microbes which produce them, complicates matters very greatly. The disease described by Schütz as *Schweineseuche* is essentially a localized dis-

ease, involving the lungs only. There are no lesions of the intestinal tract. Is, then, this *Schweineseuche* the same as the pneumonia which we have found? Let us compare for a moment the microbes. Both destroy mice, the microbe of *Schweineseuche* more speedily and invariably. The same may be said of rabbits. Inoculation on the ear caused death in one to three days, according to Schütz. The same mode of inoculation produced death with the American form in nine days, and even subcutaneous inoculations do not prove fatal in less than three days.* Guinea-pigs are only in part susceptible to both microbes; pigeons to both when large quantities of virus are introduced into the system. Fowls are killed by the American form in large doses. Schütz does not report the use of large doses with these birds. Both produce extensive pathological changes at the point of inoculation in the susceptible animals.

When we come to their effect upon pigs after subcutaneous inoculation marked differences are manifested. Pigs inoculated by Schütz died from one to three days after inoculation. Besides producing rather severe local reaction, the bacteria had multiplied in all the internal organs and were easily demonstrable in cover-glass preparations. Those inoculated with the American form at the experimental station died in from one to two weeks. The quite constant pathological change consisted in acute contraction or cirrhosis of the liver, followed by jaundice. The bacteria had been meanwhile destroyed, for cultures from such cases remained sterile. Feeding either in cultures or in animal tissues failed to produce the disease. Schütz succeeded, however, in producing pneumonia from inhalation of cultures. Our experiment failed, perhaps, because the spraying was not continued long enough.

These differences, apparently very wide, may after all depend simply upon a difference in virulence; and it may be possible for us to obtain from other outbreaks a microbe which is as virulent as the one described by Schütz. There is every reason to believe that this mircobe loses its virulence very speedily in artificial cultures. This may have modified somewhat the results, since several weeks elapsed from the time the cultures were prepared from the affected animals to the time when the pigs could be inoculated therewith.

Schütz† and others‡ are inclined to regard the microbe of *Schweineseuche* identical with the one which has been found to produce septicæmia in rabbits. In this connection it is of interest to mention briefly some experiments§ made with a microbe obtained from rabbits, which seems to be closely related to, if not identical with, the microbe of rabbit septicæmia as described by European observers, and may perhaps be a modified form of the microbe found in pigs. This it resembles in form and mode of staining at the two extremities, but it is, as a rule, somewhat larger. It also differs in forming a more or less complete membrane at the surface of the culture liquid two or three days after inoculation. In its effect upon animals, that upon rabbits is especially characteristic. It destroys them within two days

*The microbe obtained from Iowa is more virulent than this, and resembles more closely the German form. These lines were written before this had been investigated.

†*Loc. cit.*

‡Huppe: Ueber die Wildseuche u. ihre Bedeutung für die Hygiene. *Berliner klinische Wochenschrift*, 1886, No. 44.

§For a detailed account, see the *Quarterly Journal of Comp. Medicine and Surgery* for January, 1887.

when injected hypodermically. There is a slight purulent infiltration at the seat of injection, varying in intensity with the duration of the disease. The bacteria are present in large numbers in all the internal organs, giving the disease the character of a true septicæmia. Fowls are insusceptible. Of seven pigeons inoculated, three died; of four guinea-pigs, one. Mice are less susceptible than rabbits, but more so than guinea-pigs.

We must regard this microbe as more virulent to rabbits and less so to other animals than the one found in pigs. As regards its effect upon the latter no extended experiments were made, excepting to note that doses of 1^{cc} culture liquid produced no effect upon two animals. Perhaps future experiments may throw more light upon the relation of this microbe to the disease of swine, which we must consider, at least for the present, as a hitherto unrecognized infectious pneumonia.

UNITED STATES NEAT-CATTLE QUARANTINE.

Whole number of cattle received at the various stations from January 1, 1886, *to January* 1, 1887.

Littleton Station	495
Garfield Station	504
Patapsco	12
	1,011

Table showing the number of cattle received at the various quarantine stations for each month of the year 1886.

Months.	Littleton Station, Mass.	Garfield Station, N. J.	Patapsco Station, Md.
January		78	
February	41	38	
March	96		
April		31	
May	28	67	12
June	19	100	
July		36	
August	62	57	
September		5	
October	120	25	
November	45	21	
December	84	46	
Total	495	504	12

Grand total, 1,011.

Table showing the different breeds of cattle and the number of each breed imported during the year.

Name of breed.	No.
Holstein	408
Black Polled Angus	115
Red Polled Angus	117
Galloways and Black Polled Angus	75
Galloway	129
Jersey	47
Highland and Black Polled Angus	44
Welch-Dean	13
Hereford	13
Aberdeen-Angus	18
Simmenthal	4
Guernsey	14
Normandy	1
Kerry	12
Danish	1
	1,011

No infectious or contagious disease appeared among the animals quarantined at the above stations during the year.

DESCRIPTION OF PLATES.

PLATE I.—Ulcerated cæcum of a pig inoculated with blood from a case of hog-cholera. The entire mucous membrane has undergone necrosis. Near the valve, in the upper portion of the figure, the early stage, that of ecchymosis, is still to be seen. The valve is slit open to show the intact mucosa of the ileum. This figure also serves to illustrate the appearance presented by the cæcum and colon when pigs have been fed with pure cultures, the only difference being that in the latter case the necrosis is at first superficial. In the figure it involves the entire thickness of the mucosa, having begun in the submucosa, whither the bacteria have been carried by the blood.

PLATE II.—Ulcerated cæcum of a pig fed with viscera from a case of hog-cholera. The cæcum is slit open to show the mucous membrane quite uniformly necrosed, with isolated deeper ulcerations. The ileo-cæcal valve is very much thickened, the mucous membrane ecchymosed and ulcerated. The lymphatic glands of the meso-colon and in the angle formed by the entrance of the ileum into the cæcum are purplish, with cortex engorged with extravasated blood. They illustrate the condition of the lymphatics of both thorax and abdomen in the acute hemorrhagic form of the disease.

PLATE III, FIG. 1.—Cover-glass preparations from the spleen of a rabbit inoculated with the bacterium of hog-cholera from Nebraska. Stained for a few minutes in an aqueous solution of methyl violet, mounted in xylol-balsal. Drawn with camera lucida, Zeiss $\frac{1}{18}$ homogeneous, ocular 3. x 1110 The bacteria are seen among diffusely stained cells. They are chiefly in pairs, in some of which the process of division is not yet completed.

FIG. 2.—Cover-glass preparation from the liver of a rabbit inoculated with the microbe of pneumonia in pigs. Stained in an alkaline solution of methylene blue. Mounted and drawn as stated in Fig. 1. The colored portion is confined to the two poles, the central region remaining colorless.

PLATE IV, FIG. 1.—Culture twenty-eight days old in a tube of nutrient gelatine of the microbe causing pneumonia in pigs. The culture was prepared from the internal organs of a rabbit which had been inoculated from a culture obtained originally from Geneseo, Ill.

FIG. 2.—Culture eleven days old of the same microbe obtained from Sodorus, Ill. Both natural size.

FIG. 3.—Colonies of the same microbe on a gelatine plate seven days old. x 60. The pale peripheral zone, which appears after three or four days in beef infusion peptone containing 10 per cent. gelatine, together with darker granular nucleus, is very constant.

FIG. 4.—Gelatine tube culture from the blood of a rabbit inoculated with a culture of the hog-cholera bacterium from Sodorus, Ill., ten days old.

FIG. 5.—Tube culture of the hog-cholera bacterium inoculated from cultures of the spleen obtained from Sodorus, Ill., fourteen days old.

In Figs. 4 and 5 the two modes of surface growth of the hog-cholera bacterium are illustrated, both distinguishable from Figs. 1 and 2. See Plate V.

FIG. 6.—Colonies of hog-cholera bacteria on a gelatine plate four days old x 100.

PLATE V, FIG. 1.—Surface growth in gelatine tubes, enlarged two diameters.

a. Bacterium of hog-cholera, growing as an irregular patch, flattened, with a jagged margin and occasional slender branches, and as a convex rounded head.

b. Microbe of pneumonia, growing as a very thin pearly patch, with lobed margin, often showing faint concentric lines when viewed obliquely. *a*, twenty days old; *b*, twenty-six days old.

FIG. 2.—Gelatine tube culture of a bacterium which resembles the bacterium of hog-cholera very closely, but which differs in its physiological properties, and which has no pathogenic effect on animals. Found associated with the microbe of pneumonia in the spleen of a pig (Geneseo, Ill.). Culture about a week old. The surface growth is very vigorous, covering after a time the gelatine completely. The peculiar mesh-work shown in the figure is a constant character.

FIG. 3.—Growth of the bacterium of hog-cholera on potato twelve days after inoculation.

PLATE VI.—Coagulation necrosis in the liver of rabbits inoculated with cultures of hog-cholera bacteria.

FIG. 1.—Cephalic aspect of the liver of a rabbit which was found dead on the sixth day after inoculation. The lighter spots are groups of acini destroyed by the growth of bacteria. The larger patch to the left shows groups of acini in which the necrosis has involved only the peripheral zone of the acini.

FIG. 2.—Liver of rabbit which died on the eighth day after inoculation. The caudal aspect is shown with two extensive patches of commencing necrosis. In both only the peripheral zone is involved, giving the discoloration a mottled appearance.

PLATES VII to IX inclusive.—Photo-micrographs of the bacteria producing hog-cholera and swine-plague. Made with the Zeiss camera, using the new $\frac{1}{12}$ apochromatic homog. immersion objective, projection ocular No. 4. Magnification 1,000 diameters. The preparations, stained either in Bismarck brown or fuchsin, were mounted in Canada balsam. Illumination from an incandescent electric lamp.

PLATE VII, FIG. 1.—Bacterium of hog-cholera. Cover-glass preparation from the liver of a rabbit inoculated with cultures from Illinois. Stained for one hour in an aqueous solution of Bismarck brown.

FIG. 2.—Liquid culture of the bacterium of hog-cholera from Illinois. Stained in Bismarck brown.

PLATE VIII, FIG. 1.—Bacterium of hog-cholera from Nebraska. From a culture in beef infusion less than twenty-four hours old, inoculated from a colony on a gelatine plate. Stained for one hour in an aqueous solution of Bismarck brown.

FIG. 2.—Micrococci of swine-plague. From a culture in beef infusion about twenty hours old. This culture was obtained from a gelatine tube culture of effusion and plastic exudate in the pleural cavity. The lungs were extensively hepatized. Stained for one hour in aniline water fuchsin.

PLATE IX, FIG. 1.—Cover-glass preparation from the liver of a rabbit inoculated with a bit of lung tissue obtained from an outbreak of swine-plague in Iowa, January, 1887. Stained in Bismarck brown for one hour, decolorized in $\frac{1}{2}$ per cent. acetic acid for a few moments. Note the polar stain.

FIG. 2.—Cover-glass preparation from the blood of a pigeon inoculated from a culture of the microbe of swine-plague from Iowa. Stained in aniline water fuchsin.

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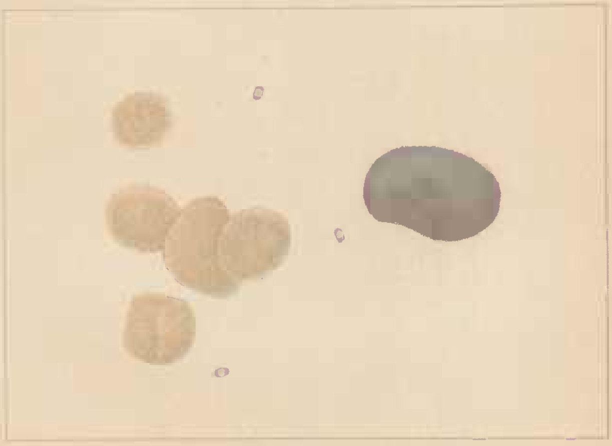
HOG CHOLERA. ULCERATED CAECUM

Plate II

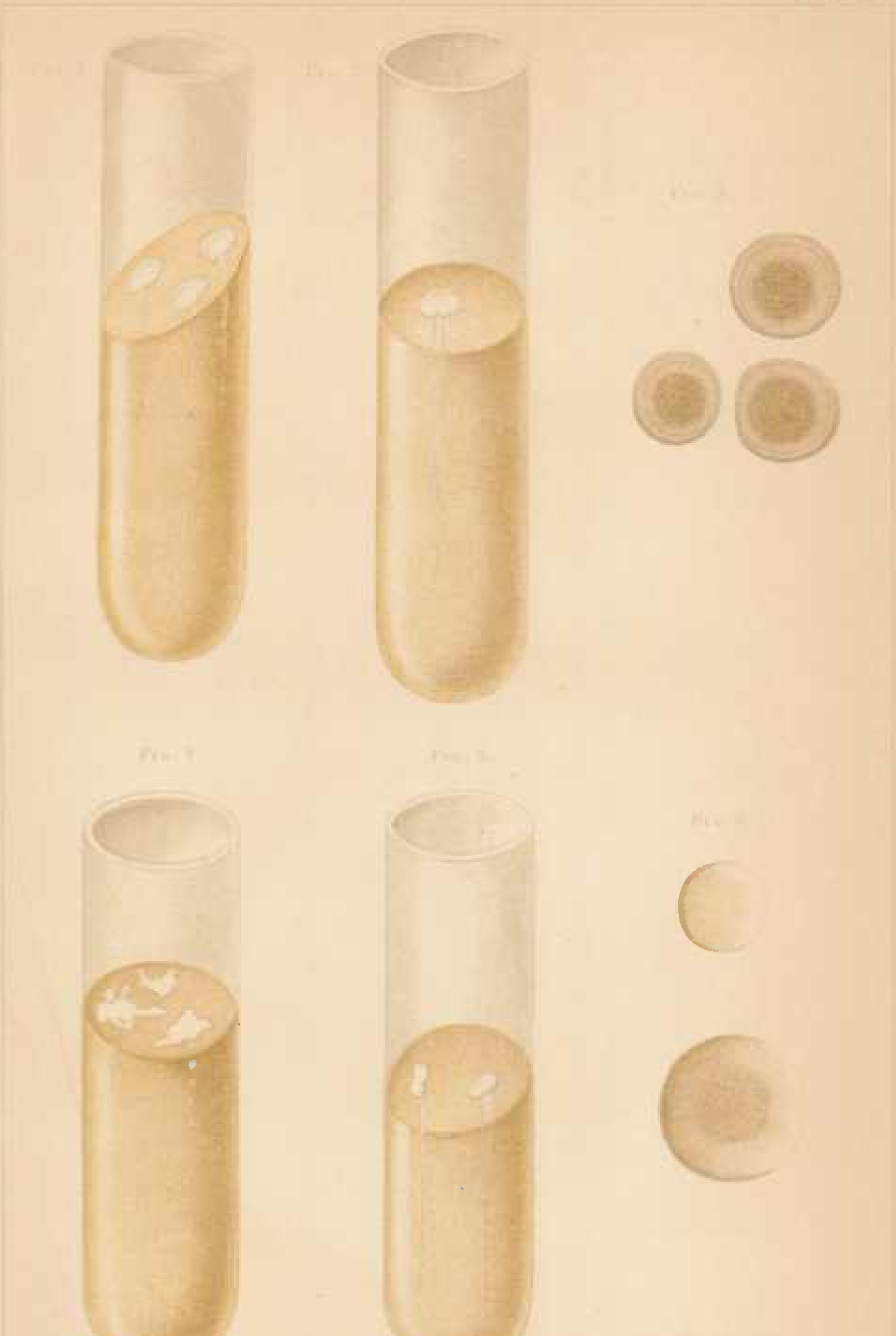
HOG CHOLERA ULCERATED CAECUM

FIG. 1.

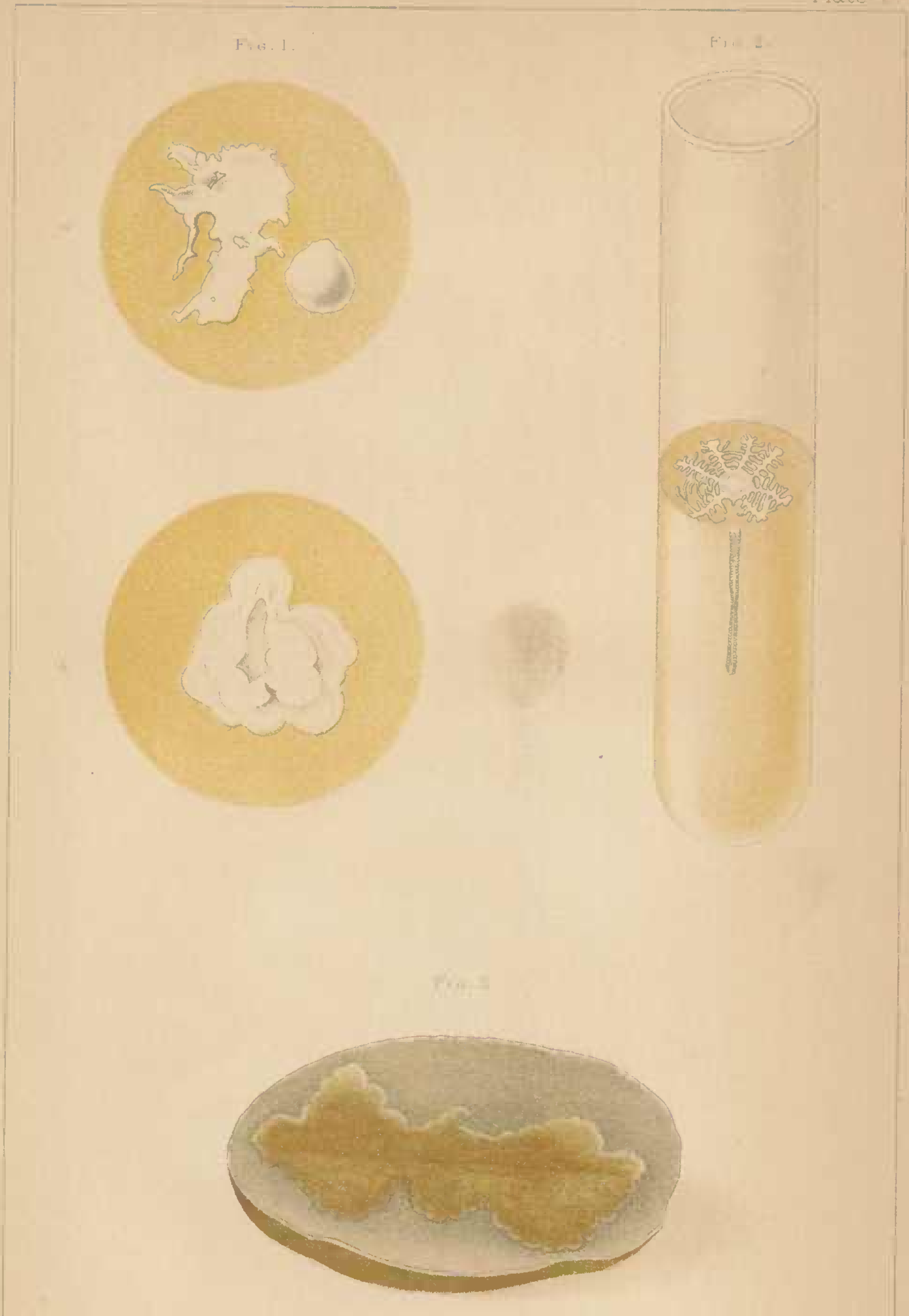
FIG. 2.



HOG CHOLERA AND SWINE-PLAGUE



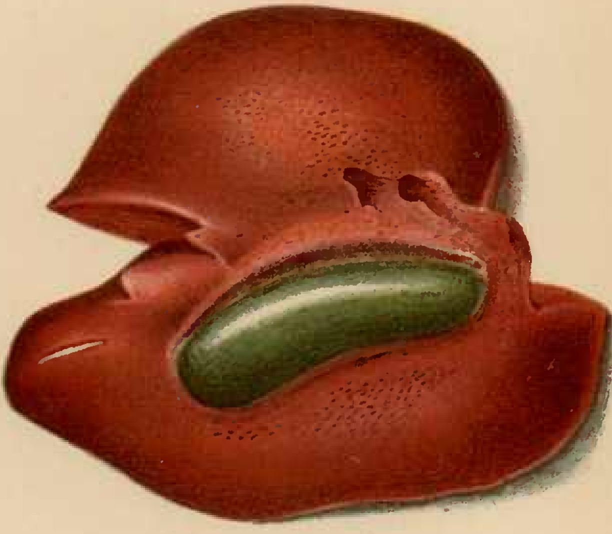
HOG CHOLERA AND SWINE-PLAGUE



HOG CHOLERA AND SWINE PLAGUE

Fig. 1.

Fig. 2.



HOG CHOLERA — LIVER OF RABBIT

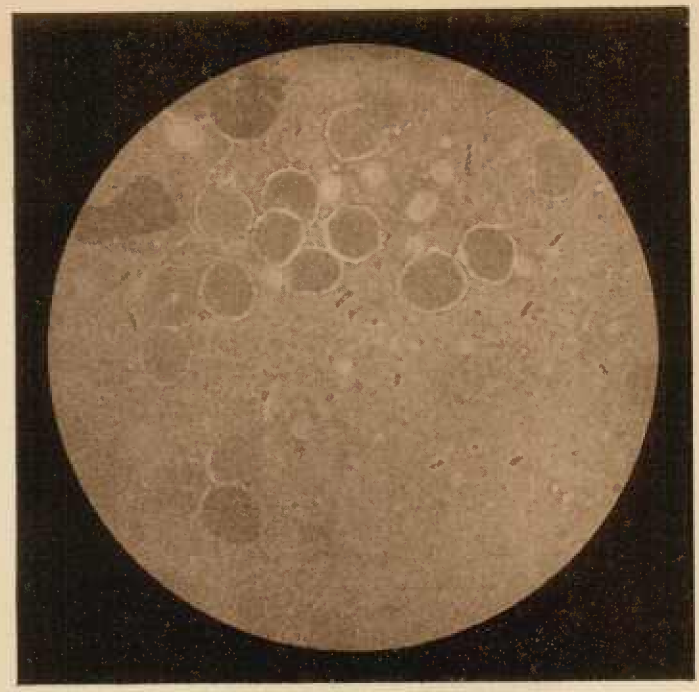


FIGURE 1.

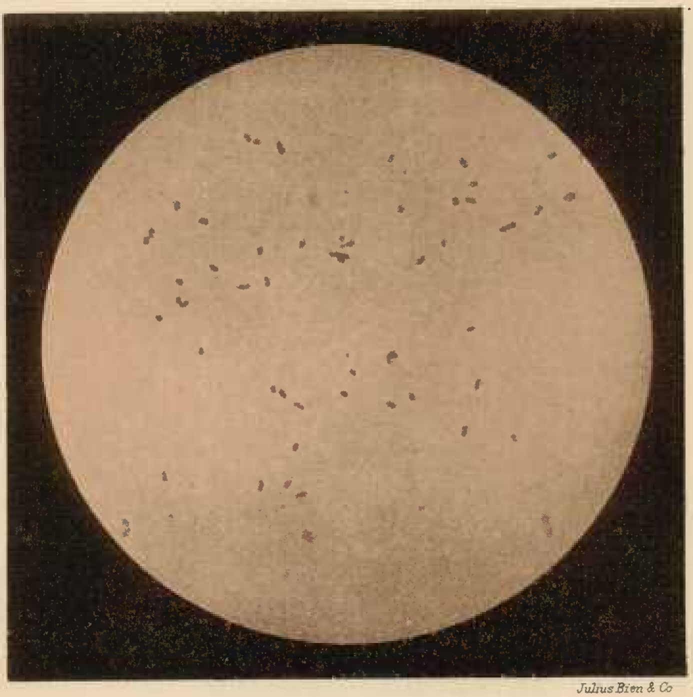


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FIGURE 2.

HOG-CHOLERA

Plate VIII

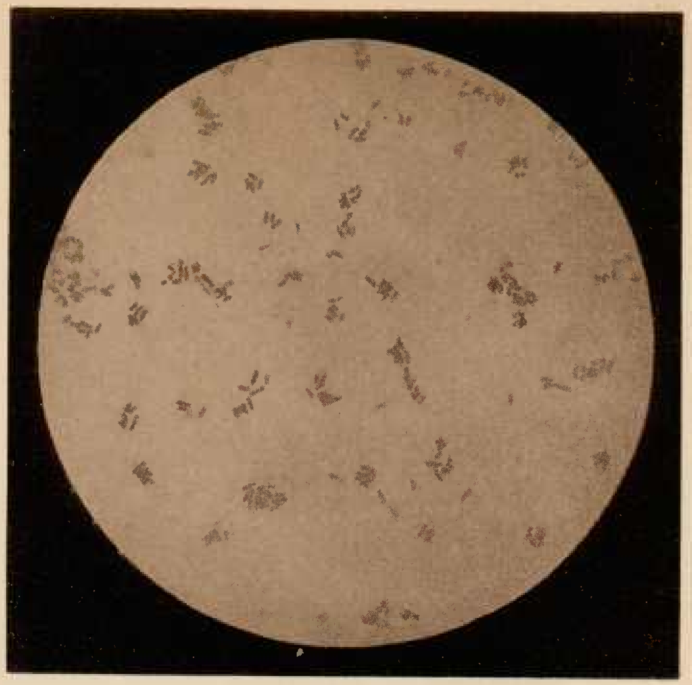

Figure 1.

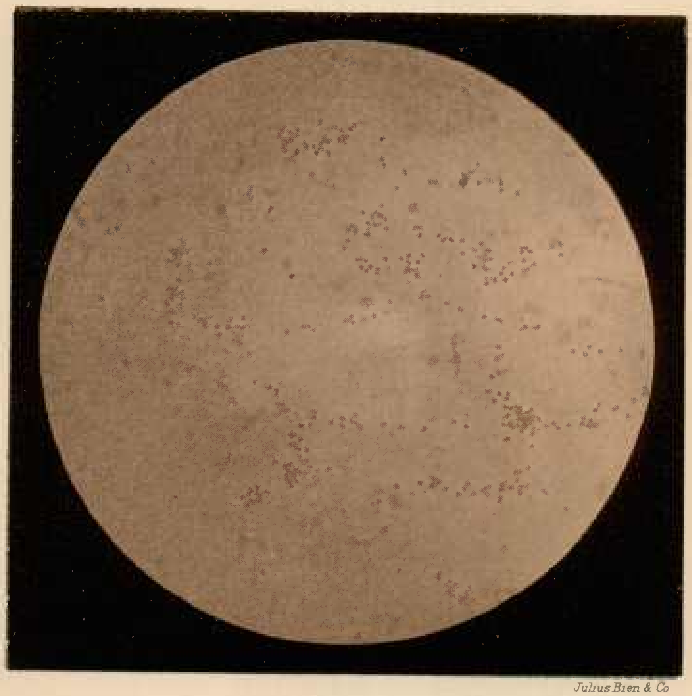

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Figure 2.

HOG-CHOLERA AND SWINE-PLAGUE.

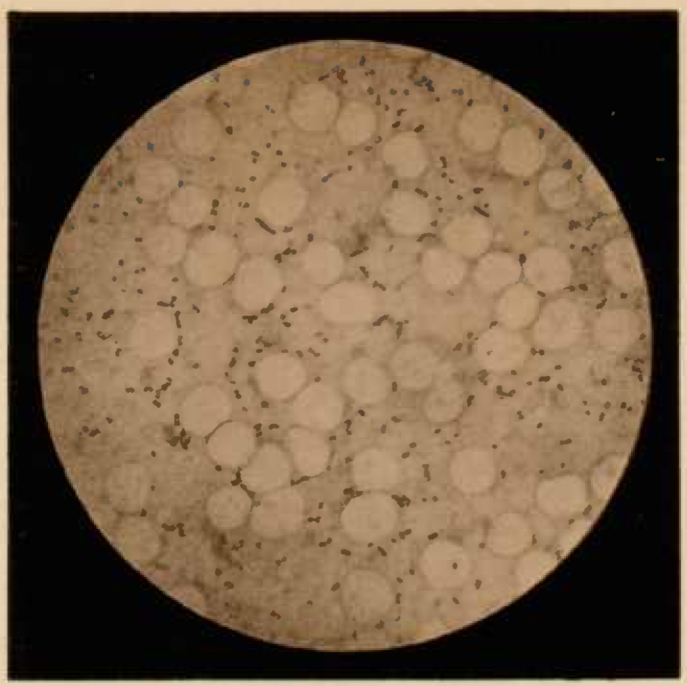

FIGURE 1.

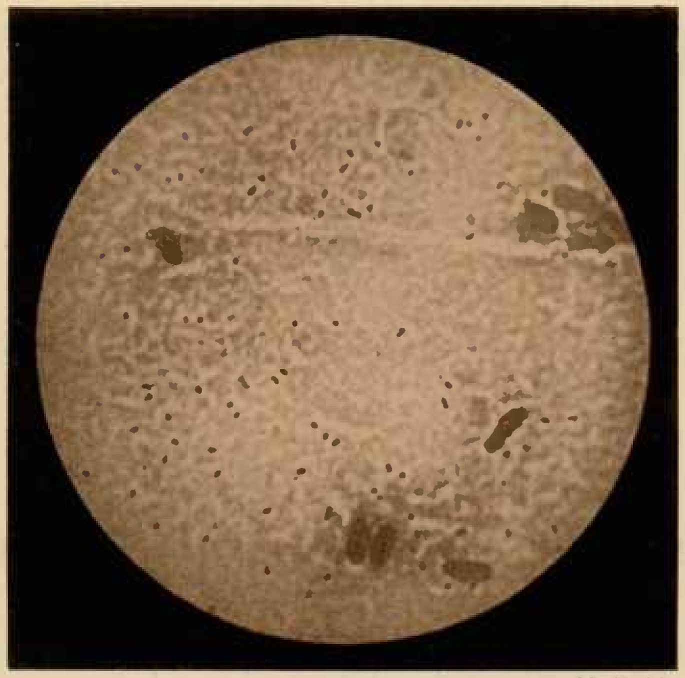

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FIGURE 2.

SWINE-PLAGUE.

REPORT OF SUPERINTENDENT OF GARDENS AND GROUNDS.

SIR: I beg to submit the following notes on matters pertaining to this division.

NOTES ON ORANGE CULTURE, ETC.

Recent visits to Florida in the interest of the Department have enabled me to acquire some knowledge of the climate, soil, and productions of that State, as far south as latitude 28 degrees. The following desultory remarks, the result of observations made, are offered for what they may afford in the way of answering some of the many inquiries constantly being directed to this division by prospective cultivators and residents of Florida.

For at least nine months of the year the climate over the larger portion of the State may be considered as being tropical, so that most of the vegetation of warm countries will find a congenial atmosphere during that period. Occasionally this tropical season is longer than that stated above, especially in the most southern parts; but there is a liability to a brief season of low temperature about the end of November sufficient to injure tender vegetation, although the weather may afterwards assume its tropical conditions for weeks. During the winter months an occasional depression of temperature, running down to or below the freezing-point, may occur at any time up to the end of February or later. These fitful periods of low temperatures are very injurious to early crops of culinary vegetables, as well as to all plants which have started into growth.

The early winter frosts are also hurtful to plants which have succulent shoots not sufficiently matured to withstand the low temperature. This is especially noticeable on young orange and lemon trees which have been subjected to constant culture or to recent applications of fertilizers, causing a stimulation to late growths. Trees of any age, if so treated, will be liable to injury from slight frost, but when the shoots of the previous season on old trees are well matured they are not sensibly hurt by frosts severe enough to injure their matured fruits; but young trees are more susceptible in this respect, so that the management of young orange groves requires a greater degree of discriminate care and consideration than is necessary with trees of deciduous habits.

Orange groves located in the neighborhood of Indian River have long been noted for their superior productions, and packages of oranges marked "Indian River" command a higher price than those from other sections of the State. Inquiries have frequently been made with a view of ascertaining the cause of the reputed superior qualities of these fruits, but answers to these inquiries have not been explicit or satisfactory. A recent visit in that section of the State, and a studied inspection of the soil, culture, and general condition of

orange trees in places where the products were typical of the best results of the region, resulted in the conviction that the superiority of the fruit was, primarily, owing to the sheltered and shaded position of the trees. The soil in which they are growing does not differ greatly from that in many parts of the State, although it contains a larger proportion of organic matter than can be found in numerous locations where orange trees are planted, but even when this deficiency is supplied on lands openly exposed to sun and winds, the products will not generally compare favorably with those from sheltered groves; so that the conclusion seems clear that the superior quality of the fruit is owing to the fact that the trees producing are afforded an ample degree of shade and protection. It may further be presumed that, in any part of the orange belt or climate where the trees are similarly sheltered, fruits may be produced equally good in every particular.

In passing through the country the effects of shelter, especially on young trees, is everywhere apparent. It might truthfully be stated that the best looking young groves are those which are best protected.

As the trees increase in height and expanse, they will, in a certain degree, shelter each other, and so far as they shade the ground and break the force of drying winds so far will evaporation of moisture be reduced; but a recognition of all the facts pertaining to the growth of the orange would tend to the conclusion that the trees would be benefited by being well sheltered, if not also partially shaded, no matter what their age may be.

What might well be termed conclusive evidence on this point is afforded by the localities in which the sour or bitter orange has become naturalized. This plant asserts itself as an example of the "survival of the fittest" of the Citrus family in this State, under strictly natural conditions of propagation and growth.

There are, throughout parts of Florida, extensive tracts of rather low lands, where the palmetto abounds and flourishes, interspersed with a variety of oaks and undergrowths. Here also is found the so-called wild or sour orange, luxuriating in and forming a part of the dense thickets, nourished by a soil rich in organic matter, and sometimes growing in places where their roots are covered with water for weeks at a time.

Some of the most valuable orange groves in the State have been formed by a partial clearing out of these thickets, removing the tops of the wild orange trees, and budding the plants with the best varieties of sweet oranges. Looking into these semi-naturalized groves we observe an indiscriminate assemblage of orange trees and tall palmettos, the latter towering above the former, which give evidence by the vivid color of their leaves and the brightness of their fruits that they enjoy the shade and protection thus afforded them. The fruit from these groves is noted for fine appearance and quality, and if intermixed with "Indian River" oranges, the task of separating them would be difficult, if not impracticable.

The comparative freedom from rust on the fruit produced in groves where the trees are afforded protection is worthy of special notice. It is attributed to the ravages of a minute insect, but I find that many persons are undecided as to whether the insect is a cause or only a consequence of a diseased condition which has been produced by other influences.

If we now direct our attention to thousands of acres of young

orange groves which may be found throughout the State, planted in sandy soils on high pine lands, and contrast their condition and appearance with those which have been described, the difference will be found as striking as it is apparent even to the casual observer.

In the preparation for planting an orange grove on pine lands the first process is that of removing all the forest trees, taking them up by the roots, and cleaning up the land so that it can be broken up with the plow. After thorough preparation by plow and harrow the soil is ready for the orange trees, which are carefully set out. Without shade, shelter, or any kind of protection from the scorching sun and the arid breezes the young trees are subjected to great vicissitudes. When rains are frequent vegetation proceeds rapidly; a week or two of dry weather intervenes and active growth receives a check for a time; the foliage of the young tree loses its vivid color, and this is considered as indicating the need of a manurial dressing; fertilizers of some kind are applied, rains follow, and growth again proceeds satisfactorily so long as sufficient moisture is present in the light sandy soil.

This somewhat erratic condition prevails in a more or less decided manner during the active growing period of the year, and may extend into the early winter with but a slight lowering of the general summer temperature, until a sudden depression is experienced, and the thermometer indicates that the freezing-point is reached. The temperature again rapidly rises, and the scorching rays of the sun, pouring through a cloudless sky, produce disastrous effects upon the frost-bitten tender shoots and leaves.

When young trees have been subjected to such casualties it is a difficult matter to prognosticate the extent of the injuries they have received; much depends upon the condition of the individual plant; but in a general way those which have shown the greatest luxuriance will suffer most. Of course injuries from frost depend upon its severity. Six to eight degrees of frost may prove fatal, even although the plants may linger between life and death for a year or two. If the sap of the plant becomes contaminated from that of the frozen shoots or branches, an early death is quite certain.

A simple precaution, and one that may be looked upon as an effectual preventive from further injury to the frost-bitten plant, is to remove the injured twigs as promptly as practicable. The longer this is delayed the deeper seated the injury becomes. The diseased portion will exhibit a discoloration in the wood, and all such parts should be removed.

The following extract from a recent publication was communicated by a well-known horticulturist and successful orange-grower, and is worthy of the serious consideration of every person contemplating the establishment of an orange grove on forest lands:

> I wish to say a word about the plan of deadening the timber instead of making a naked clearing, which is often referred to as a "shiftless cracker way." I came to Florida many years ago with these same prejudices very strong against the "shiftless cracker" deadening. I cleared off every tree and stump and planted to oranges and lemons 25 acres of heavy pine timber. I think I have learned something by experience, and I can now see that the "crackers" were right and I was wrong.
>
> A deadening is vastly superior to a naked clearing in economy and favorable conditions for the growth and health of the newly set grove.
>
> As soon as the timber is deadened it ceases to make damaging drafts on the soil, and it makes a semi-shade on the ground very grateful to the young tree in its new quarters. It also breaks the sweep of the wind, and thus decreases the evapo-

ration from the tree and the soil in which it is placed. After a while the leaves begin to come down and cover the ground with a thin mulch, retaining moisture and protecting the soil from the blazing rays of the sun. A year or more later the smaller twigs and fragments of bark are added to the leaves, and when the ground is plowed a most valuable dressing of vegetable matter is incorporated in a soil whose greatest want is humus. At the end of three years your grove is well established and the decaying timber begins to be dangerous. Then chop it down. All the branches and much of the bark will break into fragments so small the plow will dispose of them. Cut up the bodies in some ten-feet lengths and pile them in the checks mid way between the rows. In three years more the sap wood and a large part of the hearts will be thoroughly rotted and can be spread and plowed in like a manure pile. Those hearts that remain sound are valuable for posts, rails, and fuel. The cost of clearing a lot after it has been dead three years is about two-fifths of the cost of clearing green timber. In fact, the interest for three years on the cost of clearing green timber will nearly clear the deadening.

But, after all, the great gain is in the superior vigor of the young grove the first few years and the great improvement to the soil by the shade and added humus.

There are many hundreds of acres of young orange groves which would be greatly assisted by the introduction among them of some kind of tree for shelter. Additional trees would involve additional expenses for manure; the trees should therefore be of such kinds as would afford some remunerative crop. Peach trees and Japan persimmon trees might be tried, although an evergreen tree would be more valuable. The Loquat, known in many localities as Japan plum, having heavy evergreen foliage, would afford effective protection; it is also much hardier than the orange. Perhaps the olive tree might be profitably employed. Of course any trees used for this purpose would be removed when their presence was no longer required.

PLANTING A GROVE.—There are numerous methods in vogue for establishing an orange grove. That most widely adopted, according to my observation, is to set out trees three or four years from the seed.

These are produced from seeds which have been saved from good kinds, so that, in the event of the trees not being budded, they will produce fruit of at least average merit. It is well ascertained that the orange reproduces its kind more closely than does any other class of long-cultivated fruits; but there is still much difference in the qualities of oranges from groves where the trees have not been budded, a fact which purchasers of these fruits soon discover. It is questionable if this method is the best that can be followed for either of the two purposes in view; that is, whether these trees are the best for budding, and, again, whether it is advisable to trust to seedling trees for the best marketable products.

Trees of the ages mentioned are too old to be set out for budding. After being set out they are usually allowed to establish themselves for some time before being budded. By that time they have made a well-developed top of small branches, all in a healthy and vigorous condition.

The trees are budded in their main stems at points varying in their distances from the ground, and seemingly as found most convenient to the operator, and after the bud has well started the entire top of the stock is removed. This is a severe check to root extension. The plant will make efforts to restore the former balance which existed between the roots and the leaves by throwing out young shoots or suckers, which, right or wrong, are promptly removed, thus throwing the whole force of the plant into the growth of one shoot, which progresses rapidly, producing large leaves and a bulky succulent shoot; a condition which maintains until its growth is suddenly arrested by cold nights, and if frosts occur the results are disastrous.

There are thousands of orange trees in Florida, to my personal knowledge, which are in stunted, scrubby condition from causes such as those outlined above, and which should, as a matter of pure economy, be removed at once, and their places supplied by a better class of plants.

The best class of trees are those which are produced by budding healthy stocks not more than two years from seed, and when the buds have made a growth in the nursery the trees will be in good condition for permanent planting. In some countries the orange is mainly propagated by grafting; in Florida it may be said that budding is the only method practiced.

With regard to the relative merits of the sweet and the sour orange as stocks opinions are varied. The sour stock is regarded as being more hardy under low temperatures, and as withstanding greater extremes in respect to wetness or dryness of soil. The opinion which is sometimes mooted, that the sour stock impairs the sweet flavor of the fruit, does not seem to be of much importance, since it is well known that some of the best fruits are produced on these stocks. Some growers expressed an indifference as to the kind of stock they used for budding upon, but the preponderance of answers in reply to interrogatories on this point was in favor of the sour stock.

Northern orchardists find it to their advantage to procure their young fruit trees from reliable nurserymen whose business it is to propagate and supply such trees, healthy as to vitality and authentic as to name and character. Promotors of orange groves will ultimately learn that it will prove most economical and in every way to their advantage to procure their young trees from similar sources.

As to trusting to seedling trees for the best marketable products, it is found that opinions do not vary so much on this point as they did some years ago. Consumers are learning that there are differences in oranges as there are in apples, pears, and other fruits, and shipments of choice named kinds will take precedence over those which contain fruits of various merits as gathered indiscriminately from groves of seedling trees and whose uniformity cannot be guaranteed.

THE PINEAPPLE.

The pineapple cannot be considered as a perfectly safe field crop in Florida north of the twenty-eighth degree of latitude. Its cultivation is sometimes attempted a full degree north of this limit with winter protection, and unless the thermometer sinks below 30° they will pass through the winter unhurt. Being allowed ample space and freely manured the plants attain large size, and produce fruits from 4 to 9 pounds in weight, varying according to the variety.

Pineapples are commonly protected by erecting a horizontal platform of small poles or laths, supported by posts, and elevated high enough so as not to interfere with the upward growth of the plants. This platform is closely covered with palm leaves during winter, and forms a good protection against light frosts. A slight shade is allowed during summer. This, it is claimed, enhances the value of the fruit, causing it to be more tender and juicy than it would be if exposed to the full force of the sun throughout the summer. The plants are usually grown in beds 8 or 10 feet in width; the covering is thus easily applied.

North of the latitude mentioned pineapple production in the open field does not appear promising, unless in exceptionally favored places

and under the best conditions of culture. In the plantations visited, on an island near the southern junction of the Indian and Banana Rivers, the plants appeared to be set about 18 inches apart, in masses, thus preventing effective cultivation. The brown and bleached aspect of the leaves indicated injury from cold weather. The fruits are mostly small, and having to enter markets in competition with fruits of the same kind imported from the West Indies, which sometimes sell at prices not much above those given for the best oranges, the profits are not encouraging.

When the plants are allowed space for full development, and due attention given to the slight protection necessary during winter, fruits weighing from 6 to 10 pounds are produced, and these command remunerative prices.

THE JAPAN PERSIMMON.

In the spring of 1863 the Department received its first importation of seeds of persimmons from Japan through the agency of the United States legation in that country. With the view of testing their adaptability to our climate, these were sown in the open ground in drills, similar to sowing peas. They vegetated freely, and the plants attained an average size of 1 foot in height the first year, many of them reaching over 18 inches. They were slightly protected by covering the soil with leaves and strawy manure during winter. It was observed that the plants varied in their capacity to resist cold, the severest temperature of the season being 4° above zero. As growth advanced it was found that a small percentage of the plants were uninjured; the majority were killed to the surface of the ground, and all others completely destroyed. Subsequent importations of seed, when planted and grown under similar conditions, showed similar results, thus indicating that varieties differ in their ability to resist cold.

Some years after the first importation of seed it was learned that grafted plants of the best-selected varieties could be obtained in Japan from reliable sources. A small invoice of these was secured, and a number of the plants set out in a sheltered spot, with results similar to those experienced with the plants raised from seed. Some reached a fruiting condition, although more or less injured during winter. Finally, during a winter of unusual severity here, when the thermometer indicated 15° below zero, they were all killed by the extreme cold.

The first effort toward propagation was in attempting to bud these foreign kinds (*Diospyros Kaki*) in stocks of the native persimmon (*Diospyros Virginiana*). This was not successful. Grafting was then resorted to. Young stocks of the native persimmon were grafted near the ground with success. The plants progressed favorably, but they were destroyed by the severe freeze mentioned above. Only the native stock remained alive, the graft having been killed to the point of junction.

These experiences naturally led to the conviction that the Japan persimmon would not be a reliable crop in this district.

So many plants from Japan proving hardy enough to withstand the colds of northern climates, it was hoped the persimmon of that country would flourish wherever our native persimmon existed. The Department, however, carefully refrained from recommending the introduction of the best-selected varieties in northern climates; its experience with plants raised from seeds suggested caution in this respect.

The Japan persimmon may be considered as safe wherever the thermometer does not indicate a lower temperature than 12° above zero. About Norfolk, Va., and southward along the coast, it flourishes and produces abundantly. In the Southern States it does well everywhere and is rapidly gaining prominence. Its introduction as a profitable plant is extending throughout Florida, as well as in other of the Southern States, where it promises to be a fruit of some commercial importance in the near future.

The nomenclature of the imported varieties is, at the present time, quite confused. The same varieties have, from time to time, been received under different names, and some time must elapse before these mistakes can be corrected and the various synonyms properly located.

No. 41½ of the United States Consular Reports contains extensive remarks on fruit culture in the several countries. In connection with the foregoing notes on orange groves I submit the following extracts on orange and lemon culture, taken from the above official correspondence, as giving a brief exposition of the condition of this industry in foreign countries, and perhaps affording useful hints, which may be of service to those seeking information on the subject:

LEWIS RICHMOND, CONSUL-GENERAL, ROME.

Limes.—The varieties of the lime are the Jewish lime, which bears a small conical fruit; the Genoese lime, bearing a large fruit, and cultivated along the Ligurian coast; the Salo lime, cultivated at Urri, at Pegli, and at Finale Ligure; the Florentine, a hybrid of lime and lemon, cultivated in Tuscany and Liguria; and the Monster lime, which is only slightly cultivated.

Lemons.—The varieties of the lemon are the Genoese, whose fruit will stand the longest transportation; the Garden lemon, which can be forced, bearing a hardy and durable fruit; the Bergamot, a small round fruit, with a smooth thin rind, having the cells containing the essence of bergamot (this variety is cultivated at Reggio, in Calabria, and in Sicily); the Neapolitan, a small greenish fruit, very rich in juice; the Mela-Rosa, a small fruit, showing on the rind the lines marking the divisions of the lemon; and the Paradise lemon, whose fruit is very large and much used in confectionery. This latter is cultivated in the gardens of Genoa.

Oranges.—The strong or sour orange, Melangola (*Citrus Bigaradia vulgaris*), presents many varieties. The fruit called Adam's Apple belongs to this class. The principal varieties of the sweet orange are the red-juiced orange, the double-flowered, and the variegated. The culture of the Mandarin is spreading rapidly in Sicily and on the Peninsula.

Planting and cultivation.—The trees are planted on the seashore, in valleys, on plains, and on hillsides. The best results are obtained in those lands lying near the shore. Trees are grown even upon the sands deposited by the waves. They are protected from the cold sea-breezes by close hedges, walls, or netted trellises of cane, or by a thick growth of trees, especially poplars. Generally speaking, irrigation is indispensable for obtaining an abundant yield of fruit. Water is provided in various ways—by damming up springs, digging wells, making reservoirs, and by artesian wells. The water from wells is tempered by exposure to the air before using it for irrigation. Olives are frequently grown together with oranges and lemons, and are useful to these latter by reason of the shade afforded and the resulting increased dampness of the grounds.

During the six or eight years succeeding the planting an orange and lemon orchard the ground can be used for growing vegetables, as the consequent manuring and watering favors the growth of the trees.

JAMES FLETCHER, CONSUL, GENOA, ITALY.

Oranges.—The varieties of oranges generally cultivated in this province are the Mandarin, the Melangola of China, and the common Sweet.

Citrons.—Two kinds of citrons are cultivated: The *Rugosa*, having wrinkled fruit, very good for preserving, and the *Cedrato*, a very precious and aromatic fruit, also good candied.

Lemons.—The best are the *Tenno*, a lemon of gentle rind, fruit rich in acid, but

tender for transportation; the *Oblongum*, an oblong lemon, considered very valuable on account of the quantity of acid it contains.

Planting and cultivation.—Before the malady *Gomma* manifested itself it was preferred to multiply the trees by burying the ends of shoots in the ground at proper distances; these shoots soon took root. But now the seed of the sour orange is planted, into which, when the plants have grown to a proper size, the kinds desired are grafted.

Orange and lemon orchards in Liguria are all on the seacoast. Flat and hilly lands in orchard are alike protected by lofty mountains from northern winds. Orange and lemon groves can be and are cultivated inland, but the temperature in such places must not reach higher than 104° F. in summer nor lower than 32° F. in winter. Inland orchards usually do well around lakes on account of the constant climate. Groves are also to be seen on table-lands, but always on the south side of mountains. Bearing trees need a damp soil, and if the land does not contain sufficient moisture it is impossible to obtain a good crop. On naturally dry soil, therefore, water near by is of great value.

Orange and lemon groves, on account of the irregular formation of the surrounding country, are necessarily small, and they are owned by many people. The soil on which groves are planted is what the Italians term strong, and it is claimed for it that it retains moisture for a long time. An idea prevails that springs are of no great depth, and that the water courses through the earth at no great distance from the roots, and surface waterings are not needed. At Nervi, a few miles along the coast from Genoa, orchards thrive with but little irrigation, and this state of affairs is noticed even in the driest seasons. Unless groves have strong soil, as above mentioned, and are moistened by an unseen water-course, they will prove unprofitable if the owners do not nourish the roots as often as once in eight days.

Oranges and lemons are not raised in such quantities in this consular district as to admit of large exportation.

GEORGE RAYSON, CONSULAR AGENT, MARSALA, ITALY.

Oranges.—The varieties grown are Mandarins, Vaniglia, Blood, Seville, and common Sicilian, of which the Mandarins are considered the most valuable. The trees are produced from seeds of the bitter orange, and budded with selected varieties afterward. The trees are troubled with lice, to destroy which flour of sulphur is used. The gum disease also affects the trees, and this is cured by peeling off the bark which has become diseased. Trees do best at a distance from the sea, where, sheltered from all strong winds, yielding best in a valley. No orange orchard here thrives near the sea, and no trees are planted within a mile or two of the seashore. The groves are watered by artificial means, and up to the age of five or six years proprietors generally grow vegetables between the rows of trees.

Orange and lemon trees produce two hundred fruits at five years after budding; after that, if healthy and well cultivated, each tree is expected to produce one thousand.

The cost of cultivation is difficult to determine; it is very much dependent upon facilities and arrangements for watering. The average cost may be calculated at $30 per acre per annum.

ALBERT WOODCOCK, CONSUL, CATANIA, SICILY.

Oranges.—Of these there are four varieties: the Round and Oval, the Mandarin and the Bitter. The oval is preferred for commerce, being more durable. The round is sweeter and larger. These two kinds are the fruit of export. The mandarin is more perishable, and is used for home consumption. The round orange begins to ripen in December, the oval in January.

The bitter orange is very hardy, and is grown for the purpose of propagating the other varieties by budding or grafting them upon its stock. Its fruit is used for the manufacture of preserves.

Orange and lemon trees begin to bear full crops when they are from ten to fifteen years old. Some say that the orange and lemon budded upon the bitter-orange stock will remain fruitful from one to two centuries; others say from fifty to a hundred years. When not thus budded upon the bitter-orange stock, but raised from the seed, the trees are short-lived. They become diseased; a gummy substance exudes from them; a disease cankerous in its nature attacks the wood, and they soon die. The budding process is generally in practice; grafting is but little resorted to.

Planting and cultivation.—The process of starting an orange or lemon grove is commenced by first planting seeds of the bitter orange, and when the young plants are one year old they are transplanted in nursery rows. When they have grown

to be about 1 inch in diameter they are removed and planted where they are to remain. When they become well rooted and growing they are budded with selected varieties. Two buds are generally inserted, and upon opposite sides of the stock.

Orange and lemon trees grow luxuriantly in the valleys, and fringe the sea-coast almost to the water line. Those orchards yield the best results which are most distant from the sea and are not of such an altitude as to be affected by the frost. The rich valleys above the sea level, where an abundance of water can be had for irrigation, abound in the best orchards. The trees near the sea are more liable to disease, and the quality of the fruit is not so good as that of the orchards more distant.

Artificial irrigation is necessary in this climate. Streams that tumble down from Ætna are utilized for this purpose. Where this is impracticable, water is elevated from wells by power.

The ground of the orchards between the trees must be cultivated; it is necessary that the ground be kept perfectly clean. The soil should be worked at least five times a year, commencing in March and ending in October.

The Sicilians regard the month of November the best time for gathering the fruit for export. The fruit is carefully picked from the tree by hand, caution being exercised not to injure it by rough handling. The fruit is gently placed in a basket lined with cloth. The box used here is generally capable of holding from 250 to 300 fruits, there being a partition in the center. It is lined with common silk paper. Each individual fruit is incased in the same kind of paper prior to boxing. The boxes are not made air-tight, but interstices are left between the boards for ventilation. Lemons gathered in the month of November and thus boxed are supposed to keep without spoiling for six months. Oranges will not keep so long. The boxes are occasionally opened and any infected fruits removed; especially is this done just prior to shipment.

During the years 1882 and 1883 there were exported to the United States from Catania 469,964 boxes, of which the invoiced value was $765,512.56.

M'WALTER B. NOYES, CONSUL, VENICE, ITALY.

Lemons.—The lake of Garda, the largest of the Italian lakes, while penetrating with its northern extremity far into the mass of the Great Alps, opens out into the plain from the south with barely the difference of level necessary to contain its waters, and the more completely it allows the warm air of the plain to penetrate into its deeply embedded mountain recesses the more completely is the tepid element sheltered and isolated from the colder currents of the north. Bathed in this genial atmosphere, the precipitous shores form a range of natural espaliers, exposed to the southern sun in all its course and enjoying a climate of their own, where the cultivation of oranges and lemons has been a profitable industry for several centuries. It is on the western shore of this lake, in the region of Brescia, that both fruits are produced with success, while to the east, and properly within the Venetian territory, the lemon only is cultivated to any extent for commerce.

An analysis of the trunk and fruit of the lemon shows in the fruit the presence of 47.48 per cent. of potassa, 22.82 per cent. of lime, and 11.57 per cent. of phosphoric acid; in the trunk, 55.13 per cent. of lime, 17.09 per cent. of phosphoric acid, and 14.76 per cent. of potassa, with smaller proportions of other substances.

Culture and propagation.—Italy is not the natural home of the orange and lemon, for while they thrive well in the open air during summer, they require protection in winter.

Propagation is commenced by sowing orange seed in rows, and the young plants are grafted with good varieties. Great care is given to the preparation of the soil where trees are to be transplanted. A broad ditch is dug out the whole length of the proposed line of trees, and the earth is broken as finely as possible. The plants are removed with a mass of earth adhering to their roots. The young trees are sheltered during the winter, and a portion of manure is well worked in about the roots of the trees in spring. The yield here is precarious, and is always liable to be prostrated by any extraordinary severity of the season. It is estimated that the average yearly yield is 500,000 lemons, worth about $3,000.

RICHARD LOWENSTEIN, CONSULAR AGENT, GRAO, SPAIN.

The system of propagation adopted in this province is that of grafting on stocks of the bitter orange. The buds for grafting are taken from the center of the tree, as it has been found that if taken from the lower part the branches of the tree produced always incline towards the earth, and young twigs are not liked, as they produce large trees, bearing but little fruit.

With regard to culture, as soon as the trees are bare of fruit the pruner commences his work. All dead branches are cut out, as also are all rickety shoots and the crooked branches which cross one another. After the pruning is finished the surface of the soil is manured and cultivated and the ground irrigated. The soil between the trees is plowed slightly twice during summer, but not after the month of October, when the fruit begins to turn yellow. If the weather be cold the grove is irrigated, and thus the trees suffer less. As to irrigation in general, it is the experience of cultivators about Valencia that the groves may pass from four to five weeks during the summer season without being irrigated. In the winter the ground can be well left for eight or nine weeks without irrigating.

Among the diseases of the orange tree the *Mal de Goma* is the most to be feared. This disease consists of a gummy oozing, generally occurring either in the spring or in the autumn. It attacks either the trunk of the tree just above the surface of the soil, or else the roots themselves. This disease commences to show itself by some drops of gum appearing on the trunk, which still appears sound; but this spilling continues increasing, the bark is perforated, and the flow of gum augments, being fluid, turbid, and grayish in color; the bark then raises, drying or rotting on the roots, and the plant, which commences turning yellow, weakens and dies.

Recent studies of this disease have proved that its existence is to be attributed to a microscopic fungus belonging to the group of spheroids. The best remedy for it is sulphurous acid, mixing 15 bulks of the acid, concentrated at 66° Baumé, with 100 liters of water.

ERNEST L. OPPENHEIM, CONSUL, CADIZ, SPAIN.

The orange tree, when raised from a cutting (which is the most usual mode), comes into bearing five years after planting, though the acme of productivity is not reached with most varieties before some ten or twelve years more. How long they remain fruitful is an undetermined question; that is to say, when the trees are in favorable environment and well cared for. There are in the garden of the Alcazar, at Seville, several orange trees yet in bearing to which very old age is attributed, one being said to have been planted at the time of King Pedro I, about 1350 to 1366; several others dating from the time of Charles I are in a better state still. The age ascribed to them is about three hundred and forty years.

Propagation and cultivation.—The trees are occasionally raised from seed, but this mode, although practiced by careful growers, is not generally resorted to in this district on account of the longer time required in bringing the orchards into bearing. In Seville and adjacent provinces the seed of the sour orange is preferred to all others, as it appears to develop more rapidly; the trees thus raised are used for stocks upon which selected varieties are grafted.

The general mode of propagation is by cuttings. Large fine twigs of the previous summer's growth are planted, either in November or in February. In Western Andulusia the cutting is originally chosen from the variety which it is desired to reproduce, and of course no grafting is necessary. In Valencia, however, and adjacent districts the cuttings are taken from kinds which are considered best for stocks, and these are grafted or budded with the best-selected varieties.

The orange tree, which in the interior of Andalusia is hardly found beyond latitude 37° 30′, thrives on the Mediterranean coast of Spain up to 42°. This is explained by the well-known moderating influence which the vicinity of large bodies of water has upon the climate. It is generally admitted that orange culture cannot well be carried on where the mean winter temperature is much below 9° to 10° C., or where a fall below −4° C. is experienced. There are some very fine prolific orchards in the rear of Tarifa, on the Straits of Gibraltar, as well as on the delta and the lower reaches of the Guadalquivir. On hillsides or uplands the trees thrive well, provided the altitude is not such as to act virtually in the sense of latitude. It is also considered desirable to have the trees sheltered from very strong winds from any quarter. Very steep hillsides are an undesirable location on account of the insufficient retention of moisture; very low grounds are open to the contrary objection, and though large yields are frequently made in such localities, the trees are apt to suffer in wet seasons, and drainage is usually imperative.

Orange groves in Western Andalusia require irrigation during the hot season at intervals varying from ten to fifteen days, according to the greater or lesser porosity of the soil. The first irrigation commonly takes place after the dropping of the blossoms, though many practical growers recommend that it be not begun before July, alleging that irrigation before that period is generally hurtful. Irrigation is to be discontinued in October.

March is the month when plowing is first done in the orchards, at which time the irrigating ditches are restored or renewed. The second plowing takes place at

the end of May. In August the soil should be hoed thoroughly; this process to be repeated in September or October. The best growers affect the use of the harrow after each plowing, as it leaves the soil in a mellower condition, breaks up the clods, and destroys the weeds.

The raising of successive orange crops year after year must necessarily end in withdrawing from the soil all available material for such culture; hence the attention of agronomists has long been devoted to devising means for ascertaining the exact nature of the constituents withdrawn, as well as the best mode of resupplying the soil with such constituents or their equivalents in an assimilable form. The following analysis, taken from a recent treatise by the well-known Spanish agronomist, Don Luis Maria Utor, show what these constituents are and their relative quantitative proportions. The ashes of the fruit of the orange tree show the following constituents: Potash, 20.15; soda, 10.22; lime, 30.12; magnesia, 9.02; phosphoric acid, 20.04; sulphuric acid, 1.08; silicious acid, 4.50; oxide of iron, 4.25; residue unaccounted for, 0.62.

The ashes of the trunk, branches, and leaves of the orange tree show the following constituents: Potash, 14.15; soda, 16.67; lime, 31.57; magnesia, 10.64; phosphoric acid, 18.82; sulphuric acid, 4.89; silicious acid, 2.82; iron and unaccounted residue, 0.44.

The yield of orange trees, admitting all other conditions to be equal, must necessarily vary according to age and kind. In Castellon the product is stated at from 400 to 500 oranges per tree at ten years old, but full productivity is not reached before sixteen to twenty years. Very large single trees give occasionally extraordinary yields. There are in the province of Seville two colossal trees, known as "Los Migueletes," of which each has been known to yield up to 38,000 oranges in one year. Large and robust trees frequently yield from 2,000 to 5,000 each, but, on a large scale, from 800 to 1,000 per tree is all that can be assumed as a fair average yield.

H. C. MARSTON, CONSUL, MALAGA, SPAIN.

Oranges and lemons.—The trees are grafted upon stocks raised from seed from the sour orange. In the orchards they are planted about 24 feet apart. The orchards are inland, valley, and table-land, and some upland; valley and table-land yield the best results. The nearest orchards to the sea-coast are from 4 to 5 miles distant.

Artificial irrigation is commonly practiced and various methods are in vogue for distribution of water. The ground used as orange and lemon orchards is always cultivated for the growth of garden vegetables, or any food for cattle which is to be cut green once or twice a year.

In the best orange orchards an average crop would be from 80,000 to 100,000 oranges per acre per annum, the proceeds of which would amount to, in the orchard, from $200 to $250.

S. W. DABNEY, CONSUL, FAYAL, AZORES.

Oranges and lemons.—The lemon, never raised in large quantities in the Azores, has become quite extinct as an article of trade, in consequence of the liability to disease of the tree-roots.

The orange of the Azores, the China orange, is a fine fruit, but of so perishable a nature as to be incapable of resisting a long voyage.

In Fayal and Terceira it has ceased to be exported, not being able to compete in price with oranges sent from other countries in the markets of England, the only markets really within the reach of so delicate a fruit.

At the island of St. Michael, which has always been immensely in advance of the others in point of quantity produced and exported, the trade, although yet an important one, has diminished very seriously.

The varieties preferred are the Selecta and the Navel. They are grafted upon stocks raised from seed.

The orange tree at St. Michael appears to be subject to a drying up of the branches without any apparent cause and without the presence of any insect or fungus, and no remedy has yet been discovered for this disease.

It is customary to set out orange trees about 25 feet apart. The best orange gardens are some 2 miles from the coast line. The spaces between the trees are sometimes filled with corn and vegetables, but the more sagacious cultivators abstain from this. Where the garden is devoted exclusively to oranges it is hoed twice a year, but as a rule not manured, and never irrigated.

The Azorean orange has been, with few exceptions, packed in corn husks, it being found that, liable as it is to decay, the husks, being thicker and firmer than paper, protect the sound ones more effectively from a decayed comrade.

The soil of these islands, though generally thin, is fairly productive if rain does not fail too much during the summer months; and it is observed that the best oranges are raised on rather a sandy soil; those from richer ground being thicker skinned and deficient in flavor.

The climate is decidedly a damp one, but equable in temperature. The mean annual temperature, deduced from three daily observations of a Fahrenheit thermometer properly placed in the shade, I found to be 62°, the maximum observed being 80° and the minimum 44°.

G. H. HEAP, CONSUL-GENERAL, CONSTANTINOPLE.

Oranges and lemons.—The orange and lemon are grafted upon seedling stocks of the wild orange, as it has been found that the wild tree bears the cold better. The trees are usually planted about 18 feet apart. Orchards and orange gardens are to be found thriving in almost every situation for the cultivation of the grape, but they give the best results when situated on hillsides or gentle slopes, where, together with a good supply of moisture underground, they are exposed to a gentle heat by day, and fresh cool breezes by night. They never prove successful when the ground is damp for long in the summer or is not properly drained. Both oranges and lemons thrive on a rich soil, and succeed well on strong clay with moderate care and attention.

Although it is not the best situation for them, both lemons and oranges can be grown close to the sea-coast; they flourish almost anywhere as long as their roots do not come in contact with salt water.

There is a system of irrigation in general use. When the trees are young they are generally well watered by hand during summer if rains are not frequent.

Oranges, when gathered for export, should not be quite ripe. Those fully formed and with the color just turning from green to yellow are chosen. They are wrapped in fine paper or in the husk of Indian corn. A tree 20 feet in height and occupying a space of about 20 feet in diameter will frequently yield from 3,000 to 4,000 oranges annually. Many trees live from one hundred to one hundred and fifty years. As lemons are more profitable to grow than oranges, on account of their keeping qualities and their being less liable to injury during voyages, their cultivation is preferred in many parts of the Levant. The lemons are gathered green; the finest are picked out and packed in cases containing about 420 fruits; also in boxes, three of which are equal to two cases, each lemon being separately wrapped in paper.

The little island of Andros produces 10,000,000 of lemons annually; they are exported to Constantinople, the ports of the Black Sea, and those of the Danube, realizing an average price of $4.80 to $5.75 per 1,000. A similar quantity of excellent quality is exported from the larger island of Chio, where they are gathered in May, and a second crop in November and December.

Great numbers of sweet lemons are grown in the islands of the Archipelago and the districts around Smyrna. The juice of these is sweet, and is much used by calico printers in patterns with dyes containing iron, to produce greater clearness in the white parts.

The greater part of the oranges are grown in Candia and in Syria, especially in the neighborhood of Jaffa. In Paros, Mitylene, Tenedos, and Samos both oranges and lemons are largely cultivated for exportation. The dried and candied rind of the bitter orange, known as "orange-peel," is largely used in flavoring confectionery.

M. M. FOTTION, CONSULAR AGENT, MYTILENE.

Every variety of orange and lemon tree is grown here, but the most valuable are the Parakila orange trees, so-called from the village Parakila, and the Kau orange trees, so-called from their blood-red color. The Parakila trees produce large fruits; the fruit from the Kau trees is very sweet. The orange and lemon trees here are either budded or grafted. They come into bearing the fourth year and remain fruitful for fifty years. Orchards are found in every place, but they yield best results on the sea-coast. No system of artificial irrigation is practiced. They prune here at the end of March, with very great attention, and they give to the tree regular, elegant, and graceful forms. As soon as the pruning is finished the working of the soil is commenced, and they dig the soil with a spade to the depth of 25 to 30 millimeters in the clear spots, but only 2 or 3 inches deep in the vicinity of the trees. Later, two or three baskets of manure are distributed around each tree, and at the end of May the ground is irrigated once in every week or two weeks, according to the season, the position, and quality of the ground in summer. Irrigation is suspended during the autumn and winter.

The value of the yield per acre per annum in the best orange orchards is about $80, and the principal portion of the orange and lemon product is for home consumption; the export is insignificant.

JACOB SCHUMACHER, CONSULAR AGENT, HAIFA, SYRIA.

Only one variety is cultivated in my district, called the "Accawy." It has the form of the round Spanish orange, with reddish-yellowish flesh; it has a fine flavor and is very juicy; it is about 3½ inches in diameter, the skin is smooth, thin, and contains considerable oil.

We have two kinds of lemons, sweet and sour. The orange is grafted upon stocks of the sweet lemon, and this is supposed to be the most profitable, as it is said to increase the size of the fruit.

Orchard trees are planted 10 to 12 feet apart in each direction. Both orange and lemon trees are planted as shrubs in such manner that several stems come out of the ground together, although there are some orchards where the trees have but one stem; those, however, planted as bushes, protect the fruit better against the influence of the wind.

The orchards are planted, as a custom, along the sea-coast, where they yield most abundantly on level land; inland orchards never do so well. As the orchards require a sandy soil, they are planted as near as one-fourth of a mile up to some miles distance from the sea-shore. Every orange or lemon orchard is cultivated by a system of artificial irrigation applied two or three times a week. The ground in orchards between trees is cultivated twice a year; in the fall, before the rain comes, and in spring, when the rainy season is over.

The value of the yield of an acre per annum of best orchards amounts to from $80 to $100. The returns would be much larger if the oranges were exported to Europe. The above statements therefore relate only to home consumption.

S. ABELA, CONSULAR AGENT, SIDON, SYRIA.

Oranges and lemons.—One variety of orange, called Bisry, is always grown from seed. All others are grafted upon the wild or bitter orange, and in two or three years after grafting begin to bear fruit.

The order of the soils best adapted to orange culture is as follows: the best being light earth, then dark loam, then sandy, and finally clayey.

All the oranges and lemons of Syria are grown very near the sea-coast, whether at Tripoli, Sidon, or Jaffa; and I know of no extensive successful cultivation more than 4 miles from the sea, and some of the orchards are within 20 rods of salt water. When the trees are set out they are placed 18 feet apart every way when the soil is good, 16 feet when the soil is only average. Trees placed behind a shelter, as another line of trees, prosper better than those exposed to severe wind.

As there is no rain from May 1 till October 1, irrigation is the only means of keeping the trees alive. Each tree is surrounded by a little bank of earth to keep the water about the tree. The trees are left without irrigation till the last of June, till the leaves curl a little, then they are watered three times for periods of seven days, and after this every fifteen days. The irrigation of the river coming from Mount Lebanon is better than from the wells, as the last has a taste of brackishness.

In good orchards the average yield is estimated at from 1,500 to 2,000 oranges per tree.

ELIE AVANIA, ACTING CONSULAR AGENT, TARSUS, SYRIA.

Oranges and lemons.—These are merely distinguished as Sweet and Sour. The most valuable are the sour lemon and the sweet orange fruits, the usual value of which is from 1 to 3 cents each. The trees are grafted, and are planted at a distance of from 13 to 16 feet between each plant. Sour lemons and sweet oranges are most sensitive to a cold temperature, especially the former, which are sometimes completely ruined by cold.

The orange and lemon groves are generally situated in the interior or on the coast, but always in the vicinity of towns, in order to be sheltered from cold. The plain lands are rather suitable for the plantation and conservation of these trees, but the best results are obtained on the coast, where the soil is more or less sandy and light. Even at a distance of a quarter of a mile from the sea these trees prosper quite well. The system of irrigation used in this country is the running water. In those places where such water is lacking wells are dug, the water of which is used for watering the gardens by means of wheels mounted with buckets. In the places where the soil of the groves is cultivated, watering is necessary in summer

and autumn when rains are late, and this is done repeatedly. It is commonly calculated that the average yield of these trees is worth about $3 each. No exportation of oranges or lemons is made; on the contrary, large importations are made from Syria.

A. G. STUDER, CONSUL, SINGAPORE, INDIA.

Lemons.—In lieu of the usual lemon known to us in the United States, we have here the "Citronella lime," a small fruit, a trifle over an inch in diameter, of pale green color, very acid. This grows well, without much care, almost everywhere in the Indo-Malayan Archipelago and in India also; it is very plenty and cheap. This tree has the advantage of not only yielding its valuable fruits (valuable not only for cookery and lemonade, but for many medicinal purposes), but for the strongly citronella-charged leaf, out of which citronella essential oil can be extracted, forming as it does a very important article of export.

Oranges, Straits Settlements.—The cultivation of the orange here is not at all extensive, and met with here and there in fruit orchards, the trees planted closely together. The oranges are utterly unlike those produced in America or Europe. Here the orange is of deep green color, of the size of an average apple. There are two kinds, one rather sour and emitting a strong peculiar odor partly orange and citronella, and the other resembling this in color and size, but of a sweet, insipid taste.

The Pomelo, or Pampelmus, is an indigenous fruit of Indo-China, the Malay Peninsula, and most islands of the Indo-Malayan Archipelago. Its form is slightly pear shaped from the middle downwards to the stem; it is of large size, average of about 5 inches in diameter; its color is of pale green; skin thick, but peels off quite readily, and is of a slightly warted and punctured appearance. It is vinous, of sweet taste, with pleasant subacid flavor, and is a very refreshing and wholesome fruit. The color of the juice is from light to dark amber, with a reddish subtint; those from Java being the darkest colored and considered the best, and those from Siam the next best.

China oranges.—The quantity of oranges consumed in the ports is enormous, and by far the largest portion comes from China. Of Chinese oranges I have noted essentially three kinds. All of them have the true orange color and resemble the Italian orange, only that they are smaller. The first is known as the Swatow orange, and it is the largest of the Chinese oranges. Its skin is not very thick, comes off easily, and the fruit is juicy, sweet, with light subacid, and of excellent flavor. Two kinds are known as the Hong-Kong orange. One of these is called the Sucking orange, because the skin cannot be peeled off, adhering as it does close to the flesh. The other is known as the Coolie orange. It is small, like an average-sized tomato; it peels easily, but has a thick skin, and while juicy and refreshing, has rather a strong subacid taste.

Siam oranges.—The average size of this orange is a little over 1½ inches in diameter; in color it resembles a lemon rather than an orange; its skin is thinner than that of any orange known to me, and peels off with great ease; it is very juicy and fairly sweet, with hardly any subacid. They don't keep as long as any of the Chinese oranges.

JOHN A. SUTTER, JR., CONSUL, ACAPULCO, MEXICO.

Oranges and lemons.—Sweet and bitter oranges, navel oranges, lemons, limes, shaddocks, and citrons are grown here, but limes and sweet oranges are the most valuable. Some 15,000 boxes of limes are exported annually to San Francisco. Only small quantities of oranges are exported to San Francisco from December to February, before the crop from the islands in the Pacific overstocks the market.

Lime trees, which are allowed to grow like a bush, with branches rising from the roots, commence to bear at the age of four years, and are in full bearing when eight years old. Orange trees are all seedlings; they commence to bear at the age of five years and are in full bearing at the age of ten years. They are planted mostly in moist places, along small streamlets or gulches on the hillsides, in low bottoms along rivers, or near the seashore; in sandy black loam they yield the best results; the sweetest and thin-skinned oranges usually grow on hillsides, whilst the fruit of lowlands is generally thick-skinned.

Some orchards are in close proximity to the seashore, in sandy black loam, in some instances with lagoons of brackish water on the side opposite to the seashore, and give very excellent results. Thus situated, there is one orchard newly and regularly planted of 8,000 lime trees and 100 orange trees, with room for many thousands more. Few of the orchards are regularly planted; the trees are scattered here and there, without any regard to economy in land occupied, land being but of nominal

value. The ground between the trees is not cultivated, but merely kept free of undergrowth and weeds, and no system of artificial irrigation is in use.

A. WILLARD, CONSUL, GUAYMAS, MEXICO.

Oranges.—The orange commences bearing about the fourth year, and continues fruitful for twenty-five years, and is more productive in a heavy loamy soil. The bottom-lands of the valleys inland yield the best results. There are no orchards near the seashore. A system of artificial irrigation is used. Trees are usually planted 20 to 25 feet apart, and the ground in the orchards is sometimes planted in corn and vegetables. The variety grown is known as the Sicily, though climate and soil have changed it somewhat, and the variety is not clearly marked.

The oranges of this consular district are known for their sweet flavor. The production in the State is somewhat in excess of the home consumption, and some are shipped from in and around Hermosillo, over the Sonora Railroad, to Arizona and New Mexico. There is said to be a large margin of profit on the crop, now that it can be transported by rail to the United States.

GEORGE E. HOSKINSON, CONSUL, KINGSTON, JAMAICA.

Orange culture in Jamaica.—The varieties principally growing and bearing are native seedlings. Many of the trees now furnishing fruit for exportation are the remnants of those which were, prior to emancipation, planted by the slaves near their dwellings, such as the irregular groves now to be found on sugar estates and coffee plantations; other bearing trees are seedlings, which have come up spontaneously in pastures and guinea-grass pieces. Since emancipation the colored people have planted orange trees in their small freeholds in the mountains. This has been done to a large extent in the parish of Manchester, where sweet oranges of good quality have been long grown and where the soil and climate conduce to excellence in the quality of the fruit. These are admitted to be the best in the island, on account of size, sweetness, flavor, and for their good keeping qualities. It has also been maintained that they bear handling, packing, and the sea voyage to New York better than varieties grown elsewhere; for example, better than those grown on the north side of the island. The botanic garden authorities have introduced many good varieties, among others the Tangerine. These are all either grafted or budded. Seedling trees begin to bear at eight, nine, and ten years, and are in full bearing at fifteen or twenty years. Grafted or budded trees come into bearing a little earlier from the time of planting out. It is only latterly, that is, since the development of the export trade, that budding and grafting have been resorted to.

Most of the trees in pastures and on sugar estates and coffee plantations are isolated. In close plantations the distances are between 20 and 30 feet. Wider planting is preferred by intelligent growers, as tending to the best results. Tangerine oranges are planted at 22 feet apart, and larger sweet oranges at 25 to 30 feet apart.

Plantations of oranges are made principally at elevations above 1,000 feet. In Manchester the elevations will average 2,000 feet. Undulating valleys are selected on account of the greater depth of soil to be found in such spots, also on account of its greater richness. The soil principally selected is that of the white limestone formation of Jamaica geology known as "honey-comb rock." The resulting soil is a strong red earth, calcareous and ochery, owing to the presence of red oxide of iron. Orange trees yield the best results on the limestone soils, both on account of constituents promoting fertility and on account of the perfect natural drainage of such soils.

Proximity to the sea-shore is avoided. The powerful sea-breezes are hurtful to the blossoms and tender branches. At an elevation of 500 feet the sea-breeze ceases to be troublesome. The sea-shore is also too arid; and, as a rule, the soil of the coastline is sterile and unsuitable.

Artificial irrigation is only practiced to a limited extent in the plain of St. Catherine, and must be regarded at present as experimental merely.

The principal crop cultivated between orange trees is guinea-grass; but some of the best growers prefer to keep up a clean cultivation. The general practice, however, is to allow the grass to grow, and to keep weeds and shrubby undergrowth cut down by means of a bush-knife. In the grounds of the peasantry the whole list of cultivated crops in the tropics might be enumerated as crops cultivated between orange trees. The "yard" or "provision ground" of the peasant is generally a perfect medley of vegetable growth, including, besides orange trees, almost everything else. In such places the cultivation of the orange tree is associated with the stirring and cleaning of the ground necessary for the smaller crops.

During recent years a new character has been given to orange culture in Jamaica by systematic planting and increased attention. The climate in the elevated portions of the interior is believed to be exceedingly well adapted to the orange, and the soil also. When cultivation is bestowed the first effect is to increase the size of the fruit. Manuring is much neglected, but when manures are applied the increased yield and the more rapid growth of the tree are very noticeable.

The orange season is from September to April. Those who are experimenting with irrigation entertain the idea that the season may be controlled so as to produce fruit at any desired time of the year by its aid. The yield in a tropical climate may be described as more continuous than in a warm, temperate, or subtropical region. The tendency to continuous flowering is so strong, that every copious shower may be said to be followed by a growth of young shoots with their flowers.

FELIX A. MATHEWS, CONSUL, TANGIER, MOROCCO.

Oranges and lemons.—In any country where the medium temperature in winter is superior to 40° and in summer rises to 85° the cultivation of orange orchards can be made lucrative.

Here orange trees are planted both inland and on the sea-coast, on valleys, hillsides, and uplands. They yield best results in well-drained low-lying lands sheltered from the cold north winds. They are not particular with regard to soil; they grow luxuriantly in the sand, provided they are manured and copiously watered in the summer.

Seedlings are preferred, as they stand cold weather and yield largely. If the seeds are from the finest fruits, there will be no necessity to bud them.

The best stock for budding upon is the bitter or sour orange. There are numerous varieties of the sweet orange: the Balearic or Mallorea orange, large, smooth, thin skin, of vigorous growth; the Portugal or China orange, of less growth than the Balearic, but producing very large fruit; the orange of Nice, highly favored in Provence for its elegance and beautiful fruit; the Maltese or Blood orange is very rich, and also an abundant bearer, having a pulp stained with crimson.

The fogs and white frosts of spring sometimes cause an alteration in the orange tree, which afterwards is shown in the shape of reddish spots on the exterior part of the skin of the fruit, which render it unfit for use.

SELECTED EXTRACTS RELATIVE TO ORANGE CULTURE IN AUSTRALIA.

Without a suitable location you cannot grow oranges profitably. What is wanted is this: a sheltered site, with natural drainage and a light porous soil. One of the best groves I know of is situated in a nearly perfect basin, the rim of which is surrounded by a belt of trees. It is thus sheltered from every wind, and to a considerable extent from the morning sun, which is an important consideration. The formation of the land on this estate consists of a number of stratified sandstone shelves or natural terraces. The soil appears to be pure sand, and in some places it is quite shallow, but the trees do very well on it. The best of the soil, however, is sandy loam, and in one sheltered nook, where there is a depth of about 9 feet of this on the bank of a creek, there are four trees growing, the tallest of which is 37 feet high.

In selecting an orange site it is necessary, among other things, to see that it is favorably situated in regard to frost. Frost is very eccentric in its movements. It strikes one point and misses another close by. An air current, like a current of water, flows along till it meets any obstacle, and then, like water, it flows over or around it. Where a frosty air current meets a hill the volatile flow goes either over or around it, falling here and there on its direct course, while to the side eddies form and set up a circular motion, gradually decreasing in strength as the distance increases from the main current.

The importance of shelter in orange growing is paramount, not only as a protection against cold winds, but more particularly as shade from the morning sun. The rays of the morning sun falling on a frosted tree do much harm, and most orange-growing countries are subject to frost more or less. The Azores, a number of volcanic islands in the Atlantic, are situated between latitudes 36° 55′ and 39° 44′. The orange districts of Spain lie between the 36th and 40th degrees of latitude. Portugal can grow oranges as far north as Oporto, in latitude 41° 9′. New South Wales orange districts lie chiefly between 33° and 34°, and in Malta to 35° 50′.

No doubt most orange-tree planters of the future will seek out situations naturally sheltered, where the forest will answer as the break-wind and sun-shade, and when such situations can be found with suitable soil their value will be very great.

As to soil, in Australia a sandy loam is considered the best, and a heavy clay the

worst. In the Azores, where some of the finest oranges in the world are produced, the soil is volcanic. Orange trees grow in clay land, and in some cases do very well; nevertheless it is the worst land for oranges, in that it is the most retentive of water, very liable to crack on the surface in summer and break the fibrous roots. In addition to this, it is held that clay land produces sour fruit. The lighter the soil, the sweeter the fruit. In the orange districts of New South Wales the orange is grown on sandy loams, which, as a rule, are underlaid with marl or shale strata.

One of the oldest and most successful orange-growers in Australia explains his method of planting as follows: "I plant the orange tree as near the top soil as possible, not more than 3 inches from the surface. I collect the soil around to cover the roots. The soil under the tree should not be worked so deep as that farther away. For about three years I plow the ground, and every time I plow towards the tree, so that I collect a good depth of soil. This brings it to a nice round, and leaves a surface drain for the water. I advocate plowing until the fourth year. The tree should be planted as shallow as possible, and every time the ground wants cleaning it should be plowed towards the tree, leaving a furrow drain between the trees. My furrow drains are a foot deep. When the trees are bearing the ground is never dug up, but chipped over with a hoe—just scraped, in fact. I also bend the tap root, and sometimes put a slab under it."

Respectfully submitted.

WILLIAM SAUNDERS,
Superintendent of Gardens and Grounds, &c.

Hon. NORMAN J. COLMAN,
Commissioner.

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